

Melosira granulata was absent in all the 22 Aug collections and was less abundant on 1 Aug than 23 Jun at all but two stations, showing a steady decline in the numbers throughout the three months of the summer (Fig. 3-7). The pattern in Diatoma hiemale var. mesodon was essentially the same, with the cell numbers falling to practically zero in the 22 Aug samples (Fig. 3-8). Cyclotella striata was also almost gone by 22 Aug, but the peak numbers for this species were found in the 1 Aug samples, not in the 28 Jun samples (Fig. 3-9). A species of Gymnodinium (possibly G. nelsoni) started to appear in low numbers in the 1 Aug samples, but increased to very high numbers in the 22 Aug with the exclusion of almost everything else (Fig. 3-10). This sort of phenomenon is common in planktonic communities and the large population of this dinoflagellate will most likely be replaced by more diverse populations in subsequent surveys. Scenedesmus quadricauda var. quadrispina forms four- to eight-celled colonies and, instead of counting individual cells, colonies were recorded. S. quadricauda var. quadrispina is a common freshwater phytoplankter appearing mostly in waterbodies of low salinity. The 1 Aug samples from Stations 21 and 37 contained the only really large numbers of this species, which like most everything else, was gone almost completely by 22 Aug and was somewhat uneven in its distribution (Fig. 3-11). Agmenellum quadriduplicatum is a blue-green alga which forms microscopic flat sheet-like colonies of very regular cell arrangement. Instead of counting single cells in this species, tetrads of cells were recorded because individual cells are almost never found, but occur as tetrads which form the flat sheets when they remain together. Although only tetrads were counted, this species was still the fifth most abundant in the Patapsco River estuary, with the greatest number occurring unevenly distributed in the 1 Aug samples (Fig. 3-12). In considering the counts in general, the only pattern that can be seen is the sudden increase in numbers of Gymnodinium nelsoni (?) and the apparent decrease in other species during the late August sampling period.

The diversity values for each date show quite a bit of variability (Fig. 3-13). For the 28 Jun survey the diversities of the stations ranged from 0.5902 to 0.7826 with an average of 0.6858. On 1 Aug the range was a little higher, with a minimum of 0.6476, a maximum of 0.9070, and an average of 0.7545. The diversity of the 22 Aug survey reflects the presence of the high numbers of Gymnodinium sp. in much lower diversity values. The minimum was 0.00, the maximum was 0.5533, and the average was 0.2430. A diversity of 0.0 is possible if all the organisms found in the sample are of the same species. That was the case for Station 24 on 22 Aug 72. As was true for the cell counts, the only pattern that is evident at this time is the tremendous decrease in diversity due to the presence of large numbers of Gymnodinium sp. in that survey and very few of anything else.

These rather time-limited studies have suggested that there is nothing peculiar, special, or unusual about the Patapsco River estuary from the standpoint of the phytoplankton populations with the possible exception of the low assimilation numbers found off Sparrows Point. These low values may represent a response to industrial discharges from the steel and shipbuilding operations located adjacent to the estuary near this station. Assimilation values from all stations were relatively high, and may be a direct result of phytoplanktonic stimulation caused by adequate nutrient levels and seasonal high water temperatures acting with the longer day length and light intensity characteristic of summer conditions in this estuary.

Zooplankton

Zooplankton, especially the microcrustaceans such as copepods, play a crucial role in the trophic transfer of energy from primary producers such as phytoplankton to higher forms of aquatic life. For example, these primary consumers are used as food by secondary consumers such as crustaceans and other invertebrates and various fishes of the aquatic ecosystem.

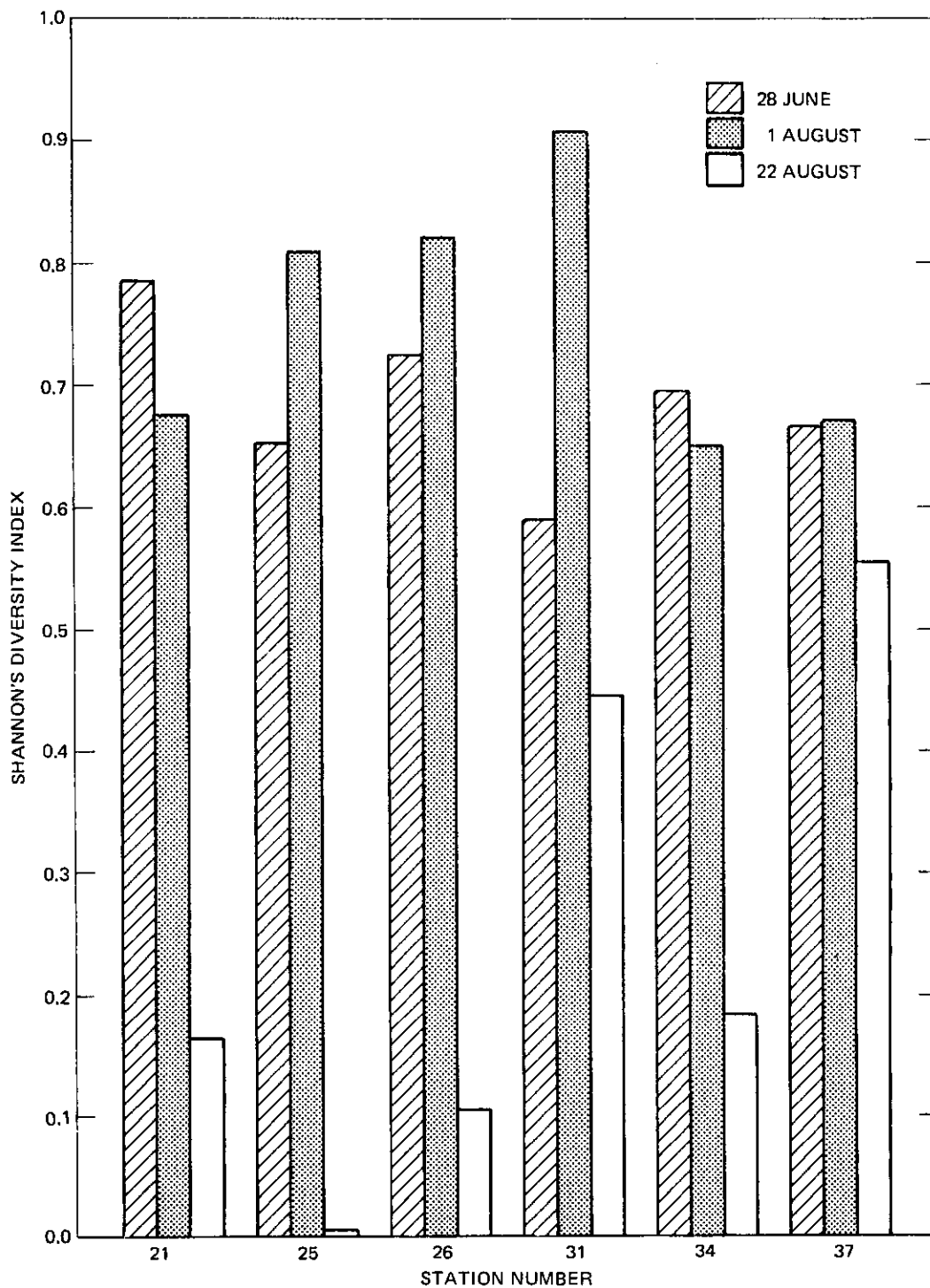


Figure 3-13 SPECIES DIVERSITY FOR EACH STATION ON EACH SAMPLING DATE IN THE PATAPSCO RIVER ESTUARY.

Copepods feed in one of several ways: (a) the mouth-parts move rapidly as the copepod swims, causing eddy currents which enable the copepod to feed (Lowndes, 1935); (b) filter-feeding copepods pass the water through a pair of appendages, which have a curtain of fine bristle-like hairs (setae and setules), and Conover (1956) observed that Acartia clausi actively use these appendages as a scoop net while swimming through the water; (c) many copepods combine filter-feeding with predation. Most copepods, which are known to be active predators, have an appendage that is more prominent than that of filter-feeding copepods (Marshall and Orr, 1961). Heinle (1972) reported that Acartia tonsa is an omnivore (both plant and animal-eating organism) that can either filter-feed or use specialized grasping appendages as a predator.

The habits of copepods follow a definite pattern which is interesting as well as important if one is to determine their distribution and abundance. There is a rhythmic daily movement of organisms from deeper water to the surface at dusk and a return to deeper waters at dawn. This is known as diurnal migration. According to McLaren (1963) this type of vertical migration is controlled primarily by light; however, it is modified by temperature variations and food availability. These factors are assumed to control the growth and development of the copepod population which, in turn, influences the biomass contributed to the ecosystem. This type of pattern, along with patchiness (e.g., the random clumping of organisms or the nonuniform distribution of organisms due to some factor or factors in the environment), present the major problems in trying to describe zooplankton abundance and distributions. Step-oblique tows were employed to try to delineate these problems, but organisms like Neomysis americana (a mysid shrimp) for example remain near the sediment-water interface during daylight hours (Herman et al., 1968) and cannot be adequately sampled; whereas Podon polyphemoides (a cladoceran), for example, remains close to the surface during daylight hours (Bosch, 1970). Therefore, due to patchiness and diurnal migrations, the numbers of organisms

expressed in cubic meters only represents what was present in the water at the time the net passed through that particular portion of the water column.

Important commercial and sport fishes, such as clupeids (herring family), serranids (bass family), and percids (perch family) depend directly or indirectly upon the estuary for food, shelter, spawning, and nursery grounds, etc. Since the zooplankton are the food link between the phytoplankton and higher organisms, it is important to determine their composition and abundance to ensure intelligent decisions concerning the use of this estuary.

Few studies have been made on the zooplankton of the Chesapeake Bay and its tributaries. Cowles (1930) studied the entire Bay and the waters immediately outside the mouth of the Bay. Wilson (1932) and Davis (1944) studied the copepods in the Bay. Goodwyn (1970) investigated the zooplankton of the northern half of the Chesapeake Bay. Herman et al. (1968) studied the seasonality and distribution of zooplankton in the Patuxent River, one of the main tributaries of the Bay. Bosch (1970) investigated the ecology of Podon polyphemoides in the Bay. Deevey (1960) and Cronin et al. (1962) reported on the zooplankton of the nearby Delaware River estuary.

Methods and Materials. Research was begun in March 1972 to investigate the zooplankton populations of the lower Patapsco River estuary. The entire water column is sampled quantitatively once a month at seven strategically located stations (Fig. 3-5). Zooplankton samples and ichthyoplankton samples were collected together by a standard 0.5 meter diameter plankton net having a #0 (505 μ m) mesh opening during the period of March through May 1972. However, since June 1972, all zooplankton samples have been collected by a #10 (153 μ m) mesh opening 0.5 meter diameter plankton net and ichthyoplankton samples by the #0 mesh net. The 0.5 meter diameter net is attached to a steel two-runner sled. Originally a TSK flow meter was attached in the mouth opening

of the net in order that results may be quantified; since June 1972, this calibration was achieved through the use of a General Oceanics digital flow meter. The R. V. Acartia is employed to pull the plankton nets through the water column at a speed of approximately 1 to 2 knots. Step-oblique tows are taken at three depths for 5 minutes each. Steps are located at the bottom, mid-water, and surface. All samples are preserved in 4% formaline, identified to species level whenever possible, and expressed as organisms per cubic meter.

Results. Table 3-11 shows a total of 17 species or groups of zooplankton identified from March through August 1972 in the lower Patapsco River estuary. Six out of the seventeen organisms captured account for 99.2% of the total organisms caught. During this same period only one species (the copepod Acartia tonsa) was captured at all stations during every survey period. The cladoceran Podon polyphemoides (also a microcrustacean zooplankton) was the second most abundant organism, accounting for 15.8% of the total zooplankton population. This species was collected during the summer months (June, July, and August). The third most common zooplankton was the copepod Eurytemora affinis, comprising 9.8% of the total catch. E. affinis was collected in each of the first five monthly sampling dates, but steadily decreased in number from spring to summer sampling periods except for July, when an increase was noted. A rotifer, Brachionus calyciflorus, was the fourth most numerous zooplankton captured. This organism was only captured in July and August and accounted for 8.1% of the total zooplankton population collected in the 6-month study period. Balanus sp. nauplii, the early states of a common barnacle generally existing in the Chesapeake Bay, was the fifth most numerous organism at 5.6%. This organism was only present during June, July, and August. A freshwater cyclopoid copepod (Cyclops sp.) rated sixth, representing 1.4%, and was found only during the months of June and July, being absent from samples collected during the other sampling periods. The other 11 organisms were found in small

TABLE 3-11
PERCENT COMPOSITION OF TOTAL ZOOPLANKTON FOR MARCH -
AUGUST, 1972 AT THE BRANDON SHORES SITE.

Organism	March	April	May	June	July	August	Total
<u>Acartia tonsa</u>	0.85	3.4	0.005	5.2	10.1	32.9	58.6
<u>Podon polyphemoides</u>	-	-	-	1.5	8.4	5.9	15.8
<u>Eurytemora affinis</u>	6.7	2.5	0.006	0.15	0.50		9.8
<u>Brachionus calyciflorus</u>	-	-	-	-	2.0	.1	.1
<u>Balanus</u> sp. nauplii	-	-	-	1.3	0.53	3.8	5.6
<u>Cyclops</u> sp.	-	-	-	0.12	1.3	-	1.5
<u>Balanus cypris</u>	-	-	-	0.06	-	0.28	0.34
Xanthidae zoea	-	-	-	0.26	0.004	0.04	0.304
Unident. Harpactocoidea	-	-	-	-	0.08	-	0.08
<u>Neomysis americana</u>	-	0.001	0.005	0.005	-	-	0.011
<u>Argulus</u> sp.	-	-	-	0.008	-	-	0.008
Unident. polychaete larvae	0.001	-	0.005	-	-	-	0.006
<u>Gammarus</u> sp.	-	0.001	0.001	0.002	-	-	0.004
<u>Leptodora kindtii</u>	-	-	0.002	-	-	-	0.002
<u>Bosmina</u> sp.	-	-	0.001	-	-	-	0.001
Anomuran larvae	-	-	-	0.001	-	-	0.001
<u>Mnemiopsis leidyi</u>	-	-	-	-	-	0.001	0.001

numbers and were very sporadic over the months at these stations, whereas the aforementioned numerically dominant organisms were consistent at all stations during the months they were found in the lower Patapsco estuary.

Other studies reported in the literature substantiate the findings that A. tonsa has been numerically the dominant organism in the Patapsco River estuary for the 6-month period of March through August 1972. Both Cowles (1930) and Wilson (1932) reported that A. clausi was the most numerous zooplankton species encountered in the Chesapeake Bay. However, in the later study, Bowman (1961) stated that A. clausi was misidentified by these previous workers and the organism was actually A. tonsa. Herman et al. (1968) reported A. tonsa to be the most abundant zooplankton species found in the Patuxent River, comprising 55.5% of the total catch. Cronin et al. (1962) in the nearby Delaware River estuary and Goodwyn (1970) in the upper Chesapeake Bay found that A. tonsa was the most persistent and abundant zooplankton species encountered in estuaries of the mid-Atlantic region.

Our studies have shown that Podon polyphemoides was the second most abundant organism found in the Patapsco River estuary during late spring and the summer through August. However, it should be noted that the current study has been in operation only 6 months, and cooler fall, winter, and early spring sampling might expand the species list and change the rank of dominant forms. The literature suggests that during the winter and early spring period, E. affinis is most abundant; therefore, it is likely that this species might become the second most abundant species in the Patapsco River on a year-round basis. The absence of A. clausi, a winter-spring copepod (Conover, 1956), might be explained by unusual water quality conditions during our study period. For example, Jefferies (1962) felt that A. tonsa was better able to propagate in low salinities than A. clausi and suggested that high salinities raise the upper lethal temperature of A. clausi. If this is so, low salinities might increase the thermal

sensitivity of this form such that normal thermal conditions in the Patapsco River estuary might be sufficient to eliminate A. clausi from the area at an early date.

The other ranking taxa, Brachionus calyciflorus and Balanus sp. nauplii are very small and could conceivably pass through a #2 (370 μ m) mesh net used in other studies reported (Herman and Cronin). Therefore, comparisons of our data with these previous studies are not possible.

Figure 3-14 represents an average number of zooplankton species from all stations sampled, and illustrates the initial numerical dominance of E. affinis (1412 per cubic meter) in March 1972. This species then declined rapidly through April and May, increased slightly in June, increased again in early August, and by late August disappeared from the study area.

As noted above, E. affinis dominates numerically during March. The increasing water temperatures probably account for the decline of E. affinis in the spring. Deevey (1948) believes the swift disappearance of E. affinis from Tisbury Great Pond (a mid-Atlantic estuary) was the result of higher summer temperatures. The increase of E. affinis in late June and early August might be explained by the unusual water conditions caused by tropical storm Agnes. The salinity of the water dropped along with water temperatures presumably promoting larger populations of these species. By late August the water temperatures and salinities rose again causing decreasing populations. Cronin et al. (1962) found Eurytemora in greatest numbers when the salinity was between 1 ppt to 10 ppt, with greatest numbers in the spring and lowest numbers in the summer. Herman et al. (1968) found that this species dominated numerically in the lower salinity ranges of the Patuxent River with highest densities in the winter-spring seasons and lowest densities in the summer. Goodwyn (1970) found that E. affinis numerically dominated the upper Chesapeake Bay in waters of 5 ppt or less. Thus the earlier studies

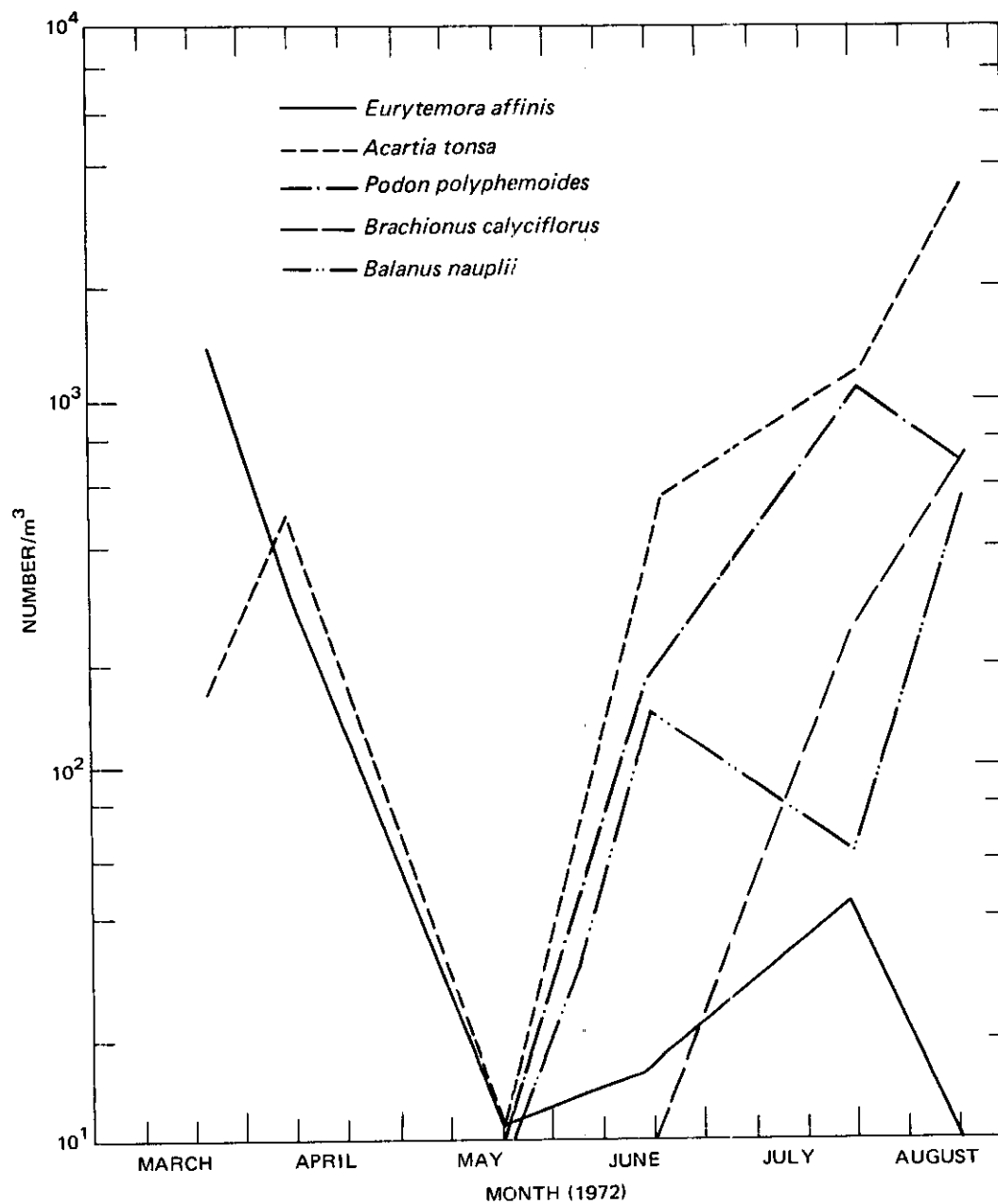


Figure 3-14 AVERAGE NUMBER OF ZOOPLANKTON PER CUBIC METER FOR ALL STATIONS SAMPLED IN THE PATAPSCO RIVER ESTUARY.

would appear to substantiate the results for our zooplankton studies in the Patapsco River adjacent to the Brandon Shores area. Research during the next 9 months should improve the reliability of these interpretations of zooplankton data collected to date.

A. tonsa was present each month of sampling although in relatively low numbers from March through May, but it increased steadily from June through August reaching maximum abundance of 4703 per cubic meter in late August. The increasing numbers of A. tonsa is probably due to the warming water temperatures. Conover (1956) and Jefferies (1962) suggest that warmer water temperatures are beneficial to A. tonsa. When A. tonsa and A. clausi are competing for the same environment, A. clausi appears to be the higher salinity - lower temperature form and A. tonsa the lower salinity - higher temperature form. Since salinities in the lower Patapsco River estuary never reach high salinity ranges, it appears that the lower salinities recorded are beneficial to A. tonsa and might explain the absence of A. clausi in the spring data. Seasonally the typical pattern is for A. tonsa to dominate in the summer-fall and A. clausi in the winter-spring populations of Acartia in the Chesapeake Bay. This is substantiated by Conover (1956), Cronin et al. (1962), Herman et al. (1968), and Goodwyn (1970). A. tonsa fits this seasonal pattern for the period of March through August 1972.

Podon polyphemoides was absent from the sample from March through May, increased in numbers in June and July to reach its maximum numbers by the first of August (1013 per cubic meter) and then decreased slightly by late August. Goodwyn (1970) reported Podon in all seasons in the southern part of upper Chesapeake Bay, but it was most numerous during the warmer months. However, Cronin et al. (1968) found Podon in the higher salinity water in fall and spring only. Bosch (1970) noted that P. polyphemoides first appears in the spring at the headwaters of shallow estuaries of Chesapeake Bay and

gradually extends to mid-Bay regions later. There the greatest densities are reached during the spring bloom, decline during the summer, and attain a secondary peak during the fall.

Brachionus calyciflorus (a rotifer) was absent from the samples until July, and then increased through August to a peak of 740 per cubic meter. The only other study to report the presence of this species (due to net mesh size) was Goodwyn (1970). He found this rotifer at his northern stations on the upper Chesapeake Bay to be most abundant during the summer. Occasionally, this species dominated numerically the samples collected by this investigator.

Balanus sp. nauplii, the early stages of a barnacle, first appeared in June, decreased slightly in July, and increased to its maximum numbers of 473 per cubic meter in late August. Cowles (1930) reported two species of Balanus in the deeper waters of lower Chesapeake Bay, but found one unidentified species as far north as the mouth of the Patapsco River. Cronin et al. (1962) found barnacle nauplii at highest densities during the spring at salinities between 20 ppt to 25 ppt with lower abundance during the summer and absence from the samples in the fall and winter. Herman et al. (1968) reported barnacle nauplii to have occurred from May to November, but the net mesh size probably allowed many of the nauplii to pass through the net. It appears that the same species found in the Patuxent River also appear in the Patapsco, but different species are found in Delaware River estuary.

Figures 3-15 to 3-17 illustrate the five most abundant organisms at three different locations and the spatial distributions of these organisms along the lower Patapsco River estuary. These three stations were combined from Stations 20-21, 24-25, and 30-31 because the transects were within several hundred yards of each other and their biological results demonstrated overlapping similarities. Stations 20-21 (Fig. 3-15) represent the upriver station, Stations 24-25 (Fig. 3-16) the midriver station, and

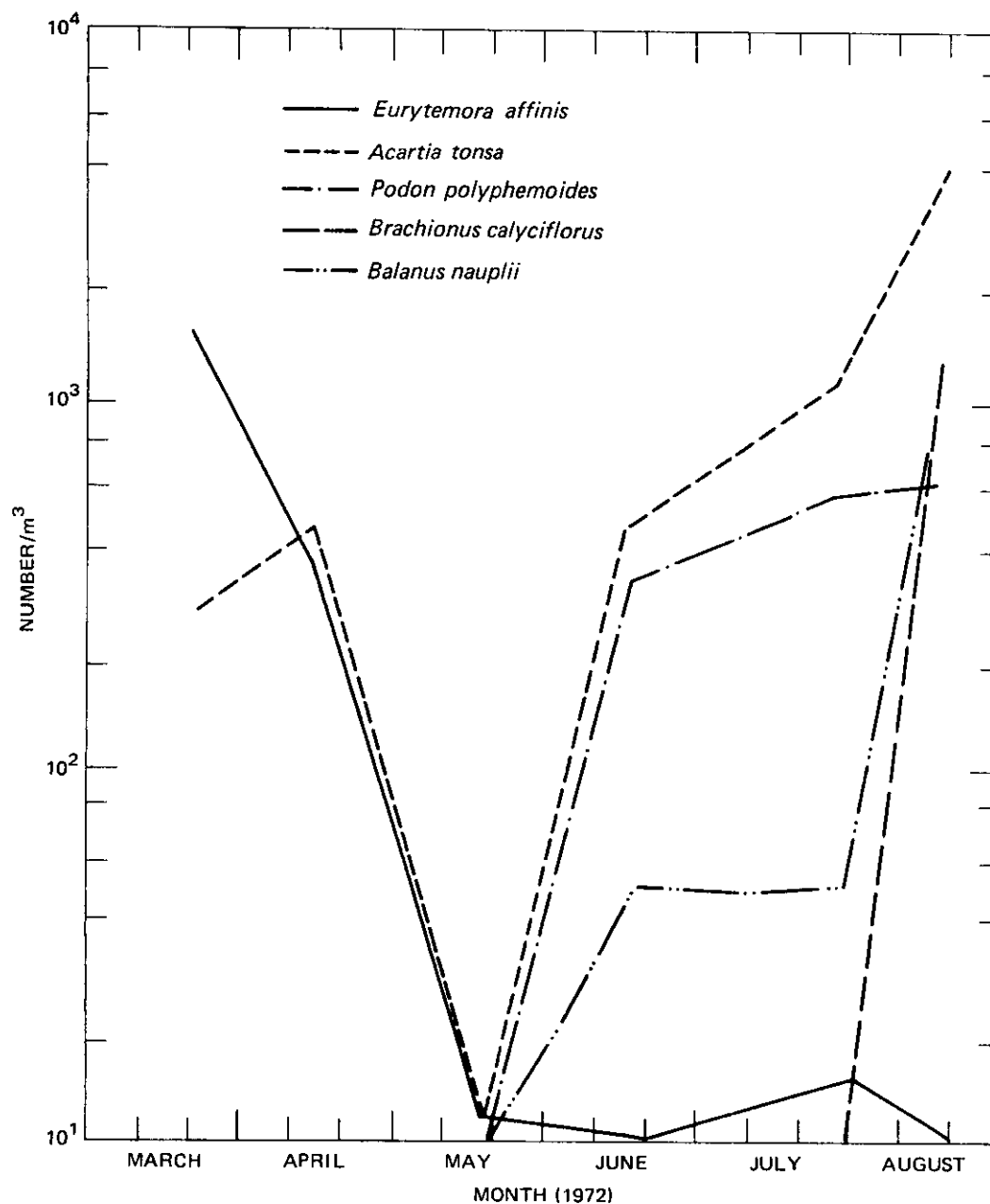


Figure 3-15 AVERAGE NUMBER OF ZOOPLANKTON PER CUBIC METER FOR STATIONS 20 AND 21 COMBINED FROM THE PATAPSCO RIVER ESTUARY.

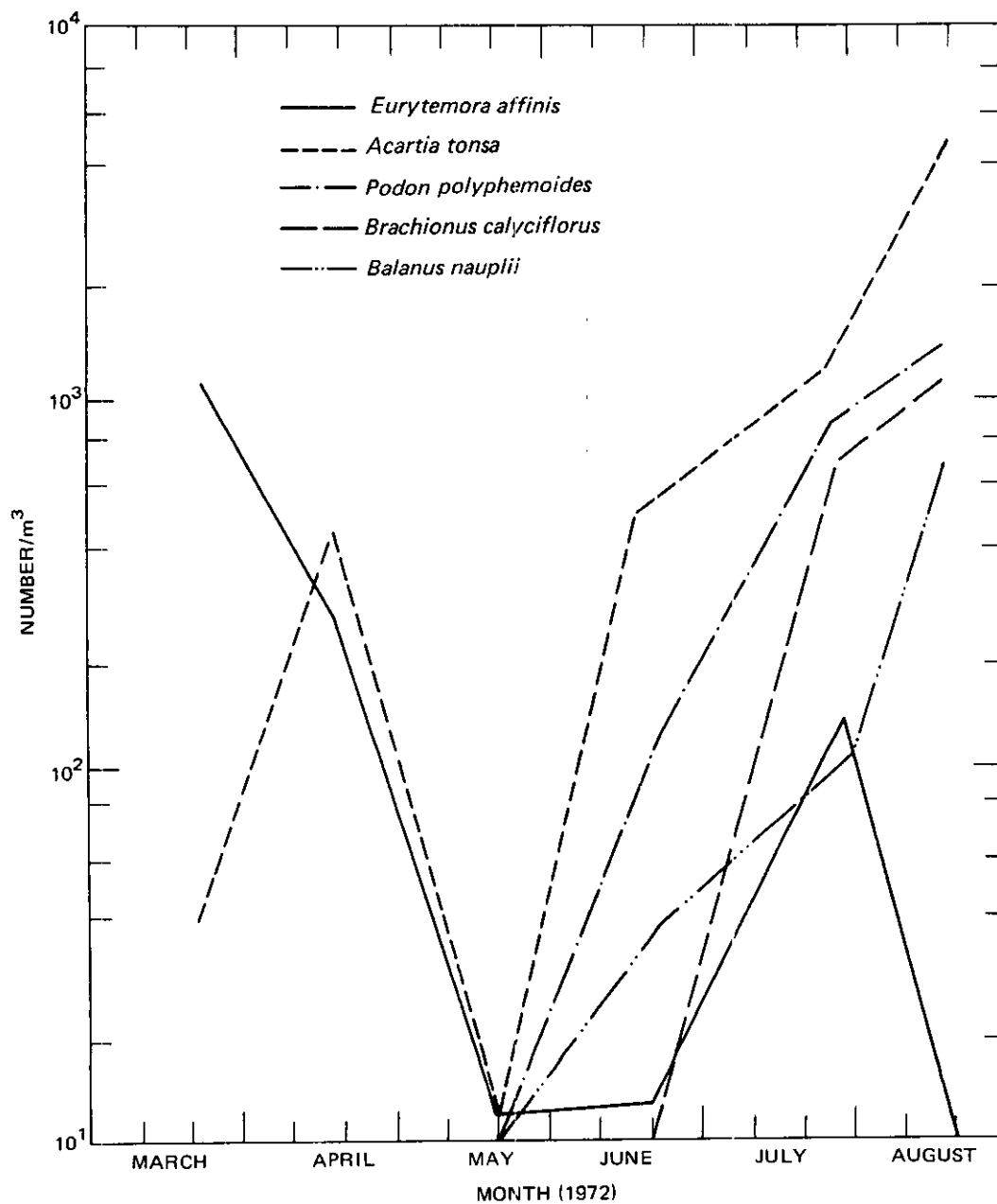


Figure 3-16 AVERAGE NUMBER OF ZOOPLANKTON PER CUBIC METER FOR STATIONS 24 AND 25 COMBINED FROM THE PATAPSCO RIVER ESTUARY.

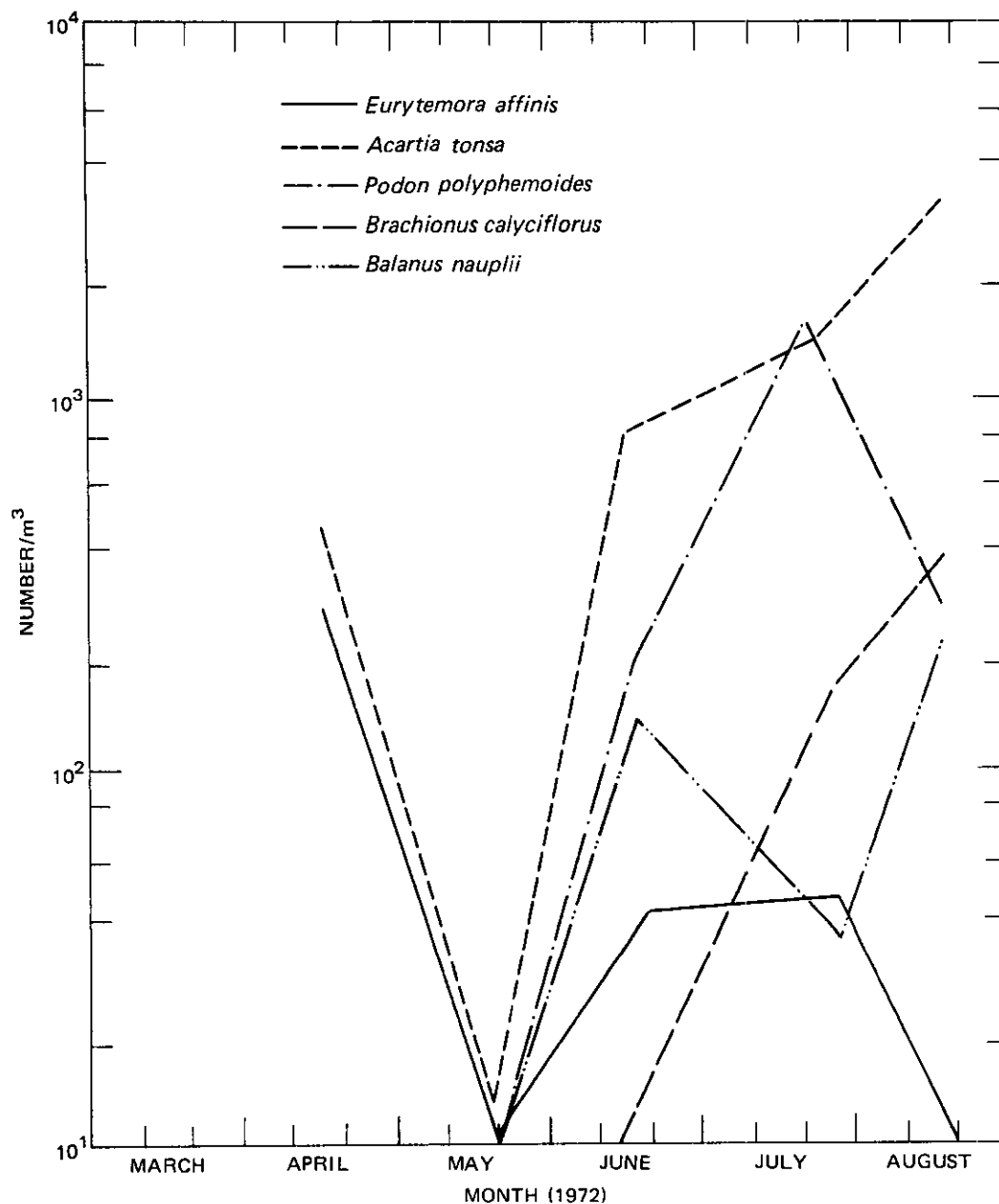


Figure 3-17 AVERAGE NUMBER OF ZOOPLANKTON PER CUBIC METER FOR STATIONS 30 AND 31 COMBINED FROM THE PATAPSCO RIVER ESTUARY.

Stations 30-31 (Fig. 3-17) the lower river station. The general trends for all three regions demonstrated that the Patapsco River estuary is homogeneous in terms of zooplankton distribution and abundance. The small discrepancies occurring between stations were most likely caused by the problems of diurnal migration, patchiness, and tidal currents.

Benthic Invertebrates

Benthic invertebrates generally represent a highly diverse and abundant group of species. Included in this group are not only the larger species of marketable crabs, clams, oysters, and mussels, but minute crustaceans, a variety of worms, snails, encrusting organisms, and shellfish. Though all benthic organisms rely on other creatures, either dead or alive, as a food source, their feeding mechanisms and modes of life are as varied as the number of species. There are scavengers (such as crabs) that feed on almost anything; parasites that are very specific and often host-dependent; filter feeders (such as clams) that pump large volumes of water through their bodies, removing organic matter; and worms that ingest sediment and remove organic material contained therein.

Although in higher salinity areas (25-35 ppt), the benthic fauna may constitute greater than 50% of the total living matter (biomass) in a marine system, low salinity estuaries are generally inhabited by fewer numbers of species in lesser numbers, but which are more tolerant to the physiological and ecological stresses. All benthic species are associated with the sediments and may crawl on the bottom, move in the sediment layers, or remain totally sessile. In comparison to other aquatic groups, benthic invertebrates are relatively stationary.

Benthic invertebrates have been used as indicators of water and sediment conditions because of their sedentary nature and their tolerance of environmental extremes.

Therefore, their response to temperature, salinity, dissolved oxygen, ionic concentration, and sedimentation may be significant. Environmental changes may be observed by studying the species over a long period of time.

The benthic fauna of the Chesapeake Bay System is composed of three types of organisms: (a) those able to live only in more saline regions found in the vicinity of the inlet to the Bay, (b) those able to live only in lower salinity areas found at the upper section of the Bay and its component tributaries, and (c) those able to live throughout the Bay system in a wide variety of salinities. More specifically, in the Patapsco River estuary, which exhibits a salinity range of approximately 2 to 10 ppt, one would expect to find organisms of the latter two types. The results of our sampling program have confirmed this presumption.

The following paragraphs include a more detailed discussion of the major types of organisms found in the Patapsco estuary.

Oligochaeta. The oligochaetes reported in the Chesapeake Bay tributaries by Pfitzenmeyer (1971) belong to the family tubificidae. These organisms are not only indicators of excessive organic enrichment, but due to their physiological makeup, are very tolerant of low levels of dissolved oxygen for relatively long periods of time (Barnes, 1969). Due to this advantage, this predominantly freshwater family exists in disproportionately large numbers in the more polluted areas of the Patapsco River estuary (Pfitzenmeyer), although they are normally found in rich, brackish regions (Wass, 1967). This particular group of invertebrate scavengers consume detrital matter in or near the sediments. Individual worms exist in a semi-infaunal mode, occasionally constructing mud tubes within which they live.

Polychaeta. Numerous polychaete species have been reported in the Chesapeake Bay System (Wass, 1965).

Polychaetes represent both infaunal (living within the sediments) and epifaunal (living on the sediments) groups. The feeding modes of polychaetes include carnivorous feeding upon soft-bodied invertebrates, detrital scavenging, and filter feeding. Polychaete worms undergo a planktonic existence during their larval stages, and are, therefore, capable of changing their distribution accordingly. Currents will largely determine the areas, direction, and velocity of such larval migration. In the Chesapeake Bay the currents flow south on the ebb tide and north on the flood tide. Thus, it is possible for polychaete larva to be carried into the Patapsco River estuary from areas both up and down the Bay.

Only the species tolerant of low salinities during all life stages will settle and reproduce in the Patapsco estuary. Dean and Haskins (1964) report Nereis succinea as being the most common species in the entire Chesapeake Bay, inhabiting the softer bottoms laden with organic debris. Dean and Haskins also report the worm Heteromastus filiformis in the bay area, and especially in very low saline estuaries. Wass (1967) reports that the above species may respond favorably to low enrichment and Warinner and Brehmer (1965) reported that H. filiformis and N. succinea were the only two species surviving in the region at a power plant outflow in August on the York River. These species are low-salinity tolerant.

Hamilton (1972) stated that polychaetes should constitute a major percentage of the biomass in all sediments in the Bay. Specifically, in the Patapsco River estuary, Hamilton found Nereis succinea a major species (ca. 400 per square meter). Pfitzenmeyer found seven species of polychaetes in the Patapsco River estuary, six of which occurred throughout the region in large numbers. A preliminary study of the Patapsco River estuary in July and August of 1971 showed a polychaeta grouping very similar to that found by Pfitzenmeyer.

Polychaetes occupy an important position in the aquatic food chain because they are soft-bodied and occur in very high numbers. Polychaetes ingest small living and dead material and are in turn fed on by larger organisms such as crabs and fish.

Crustacea - Amphipoda and Isopoda. Pfitzenmeyer reported the amphipod Leptocheirus plumulosus as being one of the most dominant species of benthic animals at the mouth of the Baltimore Harbor. Its distribution falls off rapidly through the "semi-polluted" sections, and it is not present in the upper, more polluted area closest to the Baltimore Harbor area. Preliminary sampling in the study area during the summer of 1971 indicated that L. plumulosus tolerated relatively low salinities and tended to be rather tolerant of environmental stresses common to the lower Patapsco estuary. Wass (1965) places this organism's habitat between oligohaline and mesohaline, being most at home in muddy shallows, feeding on detrital matter on the benthos. Pfitzenmeyer reported that Corophium lacustre, another amphipod, has been found in the semi-polluted portions of the Patapsco River estuary in modest numbers. Again, C. lacustre (a detritus feeder) flourishes best in marshy, organically rich areas (Wass, 1965). Amphipods have the ability to swim through the water column, but spend most of their time feeding off the substrate.

Two isopod species were described by Pfitzenmeyer in the Baltimore Harbor area. Edotea triloba was found in the "semi-healthy" areas of the Harbor in low numbers, whereas in the Chester River the numbers are more substantial. Likewise, Cyathura polita was found in large numbers in the Chester River and remained somewhat substantial in the harbor through the semi-healthy and semi-polluted zones, but only one specimen was caught in the polluted area by Pfitzenmeyer. Isopods occupy an important position in the food chain, involving a transfer of energy from the sediments upon which they feed to benthic

fish which feed upon them. Because isopods are detrital feeders, they are rarely found in the water column and are more indicative of sediment conditions.

Crustacea - Crabs. Two decapod crustacea found in the Patapsco are the economically important blue crab (Callinectes sapidus) and the mud crab Rithropanopeus harrisi).

Callinectes sapidus is commonly found in low-salinity estuaries and is described by Williams (1972) as being mainly a carnivorous scavenger. Rithropanopeus harrisi has been reported by Pfitzenmeyer in low numbers up the Patapsco River estuary to the polluted zone, closest to the City of Baltimore. Gosner (1971) states that this crab is found on a wide variety of substrates in oligohaline water areas, and may especially be found around oyster beds. Mud crabs are bottom scavengers, and like the blue crab, live on the substrate. Callinectes sapidus is capable of traveling large distances, and thus, if conditions are unfavorable, they are able to vacate waters where conditions are stressing. Particularly important is the seasonality of crab migration. During the spawning season, male blue crabs migrate to higher salinity areas and return to upper estuaries afterwards.

Mollusca. Common molluscs of the Chesapeake Bay estuary include the market oyster (Crassostrea virginica), the soft-shelled clam (Mya arenaria), the hard-shelled clam (Mercenaria mercenaria), and several species of gastropod snails including oyster drills.

Like most other invertebrates, larval molluscs spend part of their life in the water column as plankton (meroplankton). Thus, the distribution of molluscs can change due to currents and other hydraulic factors in the estuary in much the same manner as polychaetes and true plankton forms such as zooplankters and phytoplankters.

There are numerous other species of molluscs in the Chesapeake Bay estuary which vary in size and habitat (Wass, 1965). While many molluscs (such as clams) are infaunal forms, there are also epifaunal forms such as oysters and snails. Most bivalve molluscs are filter feeders, pumping large volumes of water daily, and a few that ingest detrital material. Many snails feed in a similar manner, ingesting detritus, while others are parasitic, feeding on the tissues of other invertebrates.

Pfitzenmeyer reported only one species of mollusc (Macoma balthica) occurring in high numbers in the entire Patapsco River estuary. Four other species of bivalves were found in low numbers at a few sites. Hamilton (1972) found ten species in the region of the Patapsco River estuary, eight of them different from those found by Pfitzenmeyer. Hamilton found one species, Gemma gemma, to be very common and abundant and Macoma balthica and Mulinia lateralis fairly common.

One very interesting species in the Chesapeake Bay is the brackish-water clam, Rangia cuneata. Abbott (1954) places the species range from Texas to Northwest Florida. Recently, Pfitzenmeyer and Drobeck (1964) found the species in the Potomac River estuary and Pfitzenmeyer (1971) found the clam in the Patapsco River estuary in low numbers. This species is relatively new to the Chesapeake Bay, and especially new to the upper Bay area. Our studies in the Bush River estuary have revealed dense populations of Rangia cuneata in the waters of the upper Chesapeake Bay where the salinities commonly range from 0.5 to 8.0‰. Mollusc species are important in that they often represent a major percentage of the total biomass in the sediments. These species are fed upon by crabs, parasitic gastropods, and other species.

Methods. Benthic samples were collected at stations in the Patapsco River sites on 30 Mar 72, 4 Apr 72, and 2 Aug 72 (Fig. 3-5). Samples were collected using a Modified Petersen Grab, which samples an area 12.7 by

20.3 cm (5 by 8 inches). Two grab samples were taken at each station to provide data for quantitative studies. The samples were washed in the field using a Benthic Sample Washer which has a sieve mesh size of 0.5 mm. This process removes most of the silt and clay from the samples, leaving only organisms and debris larger than 0.5 mm. A third sample was then taken at each site, a thermometer was inserted in the obtained substrata for temperature data, and the top 4 cm were returned to the laboratory for sand, silt, and clay fraction determination.

For the first two sampling dates, the samples were preserved in 70% ETOH, hand picked, counted, and identified in laboratories of The Johns Hopkins University. The latest August samples were returned to the lab alive and were floated twice in a sugar solution with a specific gravity of 1.12 in order to separate the less dense organisms from the debris. Both of these fractions were preserved in 75% ETOH. Later, the debris fraction was floated twice again so as to collect clinging organisms which resisted floating earlier during the first set of floatations. This technique is reported to be 98% efficient (Anderson, 1959; Kajak et al., 1968). Preserved in 75% ETOH, these samples were hand picked, counted, and identified as before. The obtained specimens were then placed in dry, tared crucibles by species, by station, and dessicated for at least 16 hours at 70°C (Gore, 1971). The samples were then weighed on a Mettler Balance to determine the biomass (Table 3-12). Pelecypods were weighed for total weight as well as shell weight where possible. Sediment analysis included wet sieving through a 0.61 mm, #250 Tyler screen to determine the silt-clay percentage. Future studies will include several sediment cores of the area involved, as well as further chemical analyses of the sediments.

Data with respect to decapod crustacea will be supplied in the fisheries section because Callinectes sapidus is more easily obtained from otter trawls than the Modified Petersen Grab (Table 3-13). Rithropanopeus harrisi,

TABLE 3-12 (a)
BENTHIC INVERTEBRATES FOUND IN THE PATAPSCO RIVER ESTUARY:
STATION 39--SOUTHEAST SIDE OF HAWKINS POINT, 100 YARDS OFF PILINGS

Depth: 13 feet Sediment Temperature: 24°C Percent Sand: 99.01

SPECIES	No. GB 1	No. GB 2	No. Σ GB	Σ GB Mass (mg)	No./M ²	Mass/M ²	% Comp. by No.	% Comp. by Mass
Oligochaete	1	6	7	0.1 mg	136	1.9 mg	77.8	20.0
Tubificidae								
Amphipoda								
Leptocheirus plumulosus	0	1	1	0.2 mg	19	3.9 mg	11.1	40.0
Polychaete								
Scolecoplepides viridis	1	0	1	0.2 mg	19	3.9 mg	11.1	40.0
TOTAL			9	0.5 mg	174	9.7 mg		

NOTE: When there are two biomass values for any mollusc, the first is tissue weight, the second is total weight.
Tissue weight is used in computations. *This value has been extrapolated from known values.

TABLE 3-12 (b)
BENTIC INVERTEBRATES FOUND IN THE PATAPSCO RIVER ESTUARY:
STATION 23-200 YARDS OFF SOUTH SIDE OF BRANDON SHORES DIKE

Depth: 6 feet Sediment Temperature: 25°C Percent Sand: 2.36

SPECIES	No. GB 1	No. GB 2	No. Σ GB	Σ GB Mass (mg)	No./M ²	Mass/M ²	% Comp. by No.	% Comp. by Mass
Oligochaete								
Tubificidae	27	44	71	3.8	1377	73.7	33.35	2.64
Amphipoda								
<u>Leptocheirus plumulosus</u>	23	54	77	13.6	1494	263.8	36.18	9.44
Isopoda								
<u>Cyathura polita</u>	0	1	1	0.3	19	5.8	0.46	0.21
Chironomidae	1	0	1	0.1	19	1.9	0.46	0.07
Nemertea								
<u>Carinoma trem-</u> <u>phoros</u>	1	2	3	2.1	5.8	40.7	1.40	1.46
Polychaete								
<u>Scolecoplepides</u> <u>viridis</u>	8	8	16	18.9	310	366.7	7.51	13.13
<u>Nereis succinea</u>	0	1	1	2.9	19	56.3	0.46	2.02
<u>Hypaniola grayi</u>	1	0	1	0.1	19	1.9	0.46	0.07
Mollusca								
<u>Odostomia</u> sp.	28	13	41	89.7	795	1740.2	19.25	62.29
<u>Rangia cuneata</u>	0	1	1	12.5	19	242.5	0.46	8.68
TOTALS			213	144.0	4129	2793.5		

TABLE 3-12 (c)
BENTIC INVERTEBRATES FOUND IN THE PATAPSCO RIVER ESTUARY:
STATION 26--1000 YARDS OFF SHORE OF WAGNER PLANT, BETWEEN
RED BUOY 8 AND RED BUOY 9

Depth: 12 feet

Sediment Temperature: 25°C

Percent Sand: 26.42

SPECIES	No. GB 1	No. GB 2	No. Σ GB	Σ GB Mass (mg)	No./M ²	Mass/M ²	% Comp. by No.	% Comp. by Mass
Oligochaete <u>Tubificidae</u>	93	26	119	8.4	2309	163.0	48.8	6.39
Amphipoda <u>Leptocheirus</u> <u>plumulosus</u>	51	41	92	9.7	1785	188.2	37.72	7.38
Isopoda <u>Cyathura polita</u>	1	1	2	1.9	39	36.9	0.82	1.45
Nematoda	3	0	3	0.1	58	1.9	1.23	0.07
Polychaete <u>Scolecoplepides</u> <u>viridis</u>	0	10	10	87.3	194	1693.6	4.10	66.39
<u>Nereis succinea</u>	0	1	1	8.2	19	159.1	0.40	6.24
<u>Heteronastus</u> <u>filiformis</u>	0	6	6	2.2	116	42.7	2.45	1.67
<u>Hypaniola grayi</u>	0	1	1	0.1	19	1.9	0.40	0.07
Mollusca <u>Odostomia</u> sp.	2	1	3	3.6	58	69.8	1.23	2.74
<u>Macoma balthica</u>	1	0	1	3.0	19	58.2	0.40	2.28
<u>Rangia cuneata</u>	1	5	6	25.8	116	500.5	2.45	5.32
TOTALS			244	135.3	4732	2624.8		
				131.5		2551.1		

TABLE 3-12 (d)
BENTIC INVERTEBRATES FOUND IN THE PATAPSCO RIVER ESTUARY:
STATION 33-1000 YARDS OFFSHORE OF RIVIERA BEACH

Depth: 6 feet Sediment Temperature: 25°C Percent Sand: 49.35

SPECIES	No. GB 1	No. GB 2	No. Σ GB	Σ GB Mass (mg)	No./M ²	Mass/M ²	% Comp. by No.	% Comp. by Mass
Oligochaete Tubificidae	8	2	10	3.2	194	62.1	4.31	9.24
Amphipoda <u>Leptocheirus plumulosus</u>	67	51	118	17.5	2289	339.5	50.87	50.54
Isopoda <u>Cyathura polita</u> <u>Edotea triloba</u>	4 0	5 1	9 1	2.3 1.4	175 19	44.6 27.2	3.89 0.42	6.64 4.05
Nematoda	24	5	29	0.6	563	11.6	12.51	1.73
Chironomidae	10	1	11	0.8	213	15.5	4.73	2.31
Polychaete <u>Scolecoplepides viridis</u> <u>Hypaninia grayi</u>	5 3	3 0	8 3	2.4 1.1	155 58	46.6 21.3	3.44 1.29	6.94 3.17
Copepoda	38	3	41	1.6	795	31.0	17.67	4.61
<u>Odostomia</u> sp.	2	0	2	3.7	39	71.8	0.87	10.69
TOTALS			232	34.6	4500	671.8		

TABLE 3-12 (e)
BENTIC INVERTEBRATES FOUND IN THE PATAPSCO RIVER ESTUARY:
STATION 31-2000 YARDS OFFSHORE OF ROCK POINT, BETWEEN
ROCK POINT AND NORTH POINT

Depth: 12 feet		Sediment Temperature: 25°C			Percent Sand: 99.58			
SPECIES	No. GB 1	No. GB 2	No. Σ GB	Σ GB Mass (mg)	No./M ²	Mass/M ²	% Comp. by No.	% Comp. by Mass
Oligochaeta Tubificidae	1	3	4	0.2	78	3.9	0.98	0.76
Amphipoda <u>Leptocheirus</u> <u>plumulosus</u>	46	47	93	11.6	1804	225.0	22.63	44.10
Isopoda <u>Edotea triloba</u> <u>Cyathura polita</u>	1 0	0 1	1 1	0.2 0.0	19 19	3.9 0	0.24 0.24	0.76 0.00
Nematoda	152	130	282	2.3	5471	44.6	68.62	8.74
Polychaeta <u>Scolecoplepides</u> <u>viridis</u>	5 14	5 0	10 14	2.4 0.1	194 272	46.6 1.9	2.43 3.41	9.13 0.37
Copepoda								
Mollusca <u>Odostomia</u> sp. <u>Rangia cuneata</u>	3 2	0 1	3 3	5.5 4.0 46.3	58 58	106.7 77.6 898.2	0.73 0.73	20.91 15.21
TOTALS			411	26.3	7973	510.2		

TABLE 3-12 (f)
BENTHIC INVERTEBRATES FOUND IN THE PATAPSCO RIVER ESTUARY:
STATION 34—CENTER OF THE CHANNEL, BETWEEN ROCK POINT AND
NORTH POINT

SPECIES	No. GB 1	No. GB 2	No. Σ GB	Σ GB Mass (mg)	No./M ²	Mass/M ²	% Comp. by No.	% Comp. by Mass
<u>Oligochaeta</u> <u>Tubificidae</u>	16	7	23	2.7	446	52.4	13.53	2.07
<u>Amphipoda</u> <u>Leptocheirus</u> <u>plumulosus</u>	22	39	61	5.7	1183	110.6	35.89	4.37
<u>Corophium</u> <u>lacustre</u>	5	0	5	0.2	97	3.9	2.94	0.15
<u>Isopoda</u> <u>Cyathura polita</u> <u>Edotea triloba</u>	6 0	1 2	7 2	13.3 0.9	136 39	258.0 17.5	4.13 1.18	10.19 0.69
<u>Chironomidae</u>	1	0	1	0.2	19	3.9	0.58	0.15
<u>Polychaeta</u> <u>Scolecopelides</u> <u>viridis</u>	0 21	1 35	1 56	0.2 87.0	19 1086	3.9 1687.8	0.58 32.95	0.15 66.66
<u>Nereis succinea</u> <u>Heteromastus</u> <u>filiformis</u>	1	0	1	0	19	0	0.58	0
<u>Cirripedia</u> <u>Balanus improvi-</u> <u>sus</u>	2	2	4	4.5	78	87.3	2.37	3.45

TABLE 3-12 (f) CONTINUED

SPECIES	No. GB 1	No. GB 2	No. Σ GB	Σ GB Mass (mg)	No./M ²	Mass/M ²	% Comp. by No.	% Comp. by Mass
Mollusca								
Odostomia sp.	0	1	1	0.3	19	5.8	0.58	0.23
<u>Macoma balthica</u>	4	3	7	15.2	136	294.9	4.13	11.65
				115.9		2248.5		
<u>Rangia cuneata</u>	0	1	1	0.3	19	5.8	0.58	0.23
				1.9		36.9		
TOTALS			170	130.5	3296	2531.8		

TABLE 3-12 (g)
BENTHIC INVERTEBRATES FOUND IN THE PATAPSCO RIVER ESTUARY:
STATION 38—SOUTHWEST SIDE OF FT. CARROLL, NEAR BLACK BUOY 5M

Depth: 36 feet Sediment Temperature: 22°C Percent Sand: 11.07

SPECIES	No. GB 1	No. GB 2	No. Σ GB	Σ GB Mass (mg)	No./M ²	Mass/M ²	% Comp. by No.	% Comp. by Mass
Oligochaeta <u>Tubificidae</u>	1	2	3	0.9	58	17.5	6.50	0.99
Amphipoda <u>Leptocheirus</u> <u>plumulosus</u>	6	1	7	1.9	136	36.9	15.25	2.09
Polychaeta <u>Scolecoplepides</u> <u>viridis</u>	2	1	3	2.9	58	56.3	6.50	3.20
<u>Nereis succinea</u>	4	4	8	7.1	155	137.7	17.38	7.82
Mollusca <u>Odostomia</u> sp. <u>Macoma balthica</u>	3 8	7 7	10 15	13.0 65.0* 384.3	194 291	252.2 1261.0 7455.4	21.75 32.62	14.32 71.58
TOTALS			46	90.8	892	1761.6		

TABLE 3-12 (h)
BENTHIC INVERTEBRATES FOUND IN THE PATAPSCO RIVER ESTUARY:
STATION 24-NORTH SIDE OF FT. CARROLL, NEAR RED BUOY 2

Depth: 13 feet Sediment Temperature: 24°C Percent Sand: 96.29

SPECIES	No. GB 1	No. GB 2	No. Σ GB	Σ GB Mass (mg)	No./M ²	Mass/M ²	% Comp. by No.	% Comp. by Mass
Oligochaeta <u>Tubificidae</u>	0	9	9	1.4	175	27.2	9.11	4.21
Annelida <u>Leptocheirus plumulosus</u>	0	4	4	1.6	78	31.0	4.06	4.80
<u>Corophium lacustris</u>	2	0	2	1.4	39	27.2	2.03	4.21
Isopoda <u>Cyathura polita</u>	6	4	10	5.0	194	97	10.10	15.02
Nematoda	0	4	4	0.7	78	13.6	4.06	2.11
Polychaeta <u>Scolecoplepides viridis</u>	6	17	23	2.6	446	50.4	23.22	7.80
<u>Nereis succinea</u>	2	0	2	1.5	39	29.1	2.03	4.50
<u>Heteronastus filiformis</u>	1	0	1	0.6	19	11.6	0.99	1.50
<u>Hypania grayi</u>	26	17	43	2.8	834	54.3	43.41	8.41
Mollusca <u>Rangia cuneata</u>	0	1	1	15.7	19	304.6	0.99	47.15
			99	289.4	—	5614.4		
TOTALS				33.3	1921	646.0		

TABLE 3-12 (i)
BENTHIC INVERTEBRATES FOUND IN THE PATAPSCO RIVER ESTUARY:
STATION 37—HALFWAY BETWEEN RED BUOY 12B AND SPARROWS POINT

Depth: 22 feet Sediment Temperature: 24°C Percent Sand: 3.18

SPECIES	No. GB 1	No. GB 2	No. Σ GB	Σ GB Mass (mg)	No./M ²	Mass/M ²	% Comp. by No.	% Comp. by Mass
Oligochaeta Tubificidae	4	20	24	5.2	465	101	88.89	86.67
Amphipoda Leptocheirus plumulosus	0	2	2	0	39	0	7.4	0
Polychaeta Scolecolepides viridis	0	1	1	0.8	19	15.5	3.7	13.33
TOTALS			27	6.0	523	116.2		

TABLE 3-12 (j)
BENTHIC INVERTEBRATES FOUND IN THE PATAPSCO RIVER ESTUARY:
STATION 36--SPARROWS POINT CHANNEL, BLACK BUOY 5M

Depth: 20 feet		Sediment Temperature: 23°C			Percent Sand: 3.02			
SPECIES	No. GB 1	No. GB 2	No. Σ GB	Σ GB Mass (mg)	No./M ²	Mass/M ²	% Comp. by No.	% Comp. by Mass
Oligochaeta Tubificidae	103	64	167	9.9	3240	192.1	71.68	16.00
Amphipoda <u>Leptocheirus</u> <u>plumulosus</u>	23	16	39	16.8	757	325.9	16.75	27.14
Nemertea <u>Carinoma tremen-</u> <u>phoros</u>	2	0	2	5.9	39	114.5	0.86	9.53
Polychaeta <u>Nereis succinea</u>	9	12	21	22.1	407	428.7	9.00	35.70
Mollusca <u>Odostomia</u> sp. <u>Macoma balthica</u>	2 0	1 1	3 1	5.2 2.0 28.2	58 19	100.9 38.8 547.1	1.28 0.42	8.40 3.23
TOTALS			233	61.9	4520	1200.9		

TABLE 3-12 (k)
BENTHIC INVERTEBRATES FOUND IN THE PATAPSCO RIVER ESTUARY:
STATION 35—EASTERN SIDE OF OLD ROAD BAY, NEAR FLASHING
FLASHING BLACK BUOY 9

Depth: 15 feet Sediment Temperature: 26°C Percent Sand: 3.28

SPECIES	No. GB 1	No. GB 2	No. Σ GB	Σ GB Mass (mg)	No./M ²	Mass/M ²	% Comp. by No.	% Comp. by Mass
<u>Oligochaeta</u>	1	3	4	1.1	78	21.3	6.10	3.14
<u>Tubificidae</u>								
<u>Amphipoda</u>								
<u>Leptocheirus</u>	14	14	28	5.4	543	104.8	42.46	15.44
<u>plumulosus</u>								
<u>Isopoda</u>								
<u>Cyathura polita</u>	1	5	6	2.3	116	44.6	9.07	6.57
<u>Polychaeta</u>								
<u>Scolecoplepides</u>	7	5	12	3.5	233	67.9	18.22	10.00
<u>viridis</u>	1	2	3	4.8	58	93.1	4.53	13.71
<u>Nereis succinea</u>								
<u>Heteromastus</u>	0	1	1	3.5	19	67.9	1.49	10.00
<u>filiiformis</u>	2	1	3	0.6	58	11.6	4.53	1.71
<u>Hypaniola grayi</u>								
<u>Mollusca</u>								
<u>Odostomia sp.</u>	0	1	1	2.8	19	54.3	1.49	8.00
<u>Rangia cuneata</u>	1	7	8	11.0*	155	213.4	12.12	31.43
TOTALS			66	35.0	1279	678.9		

TABLE 3-12 (I)
BENTHIC INVERTEBRATES FOUND IN THE PATAPSCO RIVER ESTUARY:
STATION 30—EASTERN SIDE OF NORTH POINT

Depth: 8 feet		Sediment Temperature: 23°C			Percent Sand: 6.81			
SPECIES	No. GB 1	No. GB 2	No. Σ GB	Σ GB Mass (mg)	No./M ²	Mass/M ²	% Comp. by No.	% Comp. by Mass
Oligochaeta <u>Tubificidae</u>	1	6	7	1.4	136	27.2	6.81	6.74
Amphipoda <u>Leptocheirus plumulosus</u>	2	0	2	0.8	39	15.5	1.95	3.84
<u>Corophium lacustre</u>	18	63	81	15.3	1571	296.8	78.63	73.56
Isopoda <u>Cyathura polita</u> <u>Edotea triloba</u>	3 0	4 1	7 1	0.7 1.1	136 19	13.6 21.3	6.81 0.95	3.37 5.28
Polychaeta <u>Scolecoplepides viridis</u>	2	0	2	0.8	39	15.5	1.95	3.84
Mollusca <u>Rangia cuneata</u>	2	1	3	0.7 2.5	58	13.6 48.5	2.90	3.37
TOTALS			103	20.8	1998	403.5		

TABLE 3-13
CALLINECTES SAPIDUS COLLECTED IN PATAPSCO RIVER ESTUARY BY
OTTER TRAWL

DATE	STATION						
	23	25	26	28	29	30	31
7 VII 71			3♂ (108, 139, 94)				
17 VII 71	1♂ (75) 1♀ (72)		1♂ (22) 2♀ (53, 58)	3♂ (123, 110, 69)	1♂ (112)		1♂ (106)
21 VIII 71			5♂ (64, 80, 122, 100, 121) 4♀ (110, 57, 82, 90)				
16 V 72						12♂ (25-37 mm)	6♂
25 VI 72						>30♂ (>137 mm)	
1 VIII 72		2♂					

likewise is more easily caught in a beach seine than in a grab. Size, sex, and numbers will be recorded.

Results. Several facts should be pointed out concerning the sampling technique, the treatment of the data, and the presentation of the data in this report. First of all, the Modified Petersen Grab is unable to effectively sample crabs that move on the substrate because crabs are able to move out from underneath the grab. However, beach seining and otter trawling techniques do collect these organisms along with the fish populations at each station. The blue crab (Callinectes sapidus) has been noted in this area of the Patapsco River estuary during a preliminary sampling effort in the summer of 1971.

The benthic invertebrate populations at each station have been tabulated in tables in terms of numbers of individuals per square meter (Table 3-12). It should be noted that the field data is not collected on a square meter basis, but converted to it. Thus, a value of 19 organisms per square meter represents the occurrence of the species once in two grab samples. Values of this order of magnitude may thus be accounted for by sampling error. Moreover, during counting the numbers of organisms, soft-bodied types such as worms often occur as pieces and parts. A piece of an organism is not counted as one individual unless it includes the head region. However, all portions of these invertebrates are used in computations of the biomass at each station.

Finally, the benthic stations have been located by chart and map and not by marker buoy. Experience has shown that buoys do not remain at the intended location, but are removed by both the public or by turbulence and other hydraulic forces. Thus, when sampling, it is highly unlikely that the exact position can be located each time, but nevertheless, considerable effort is made to sample as close as possible to the original designated station.

Table 3-14 presents the data collected thus far for both sampling dates in terms of organisms per square meter, as well as the species distribution. It is apparent that the five most occurring species, Tubificidae (several species), Leptocheirus plumulosus, Scolecopides viridis, Nereis succinea, and Odostomia sp. are also the most abundant species, comprising a major part of the biomass at six or more stations on both sampling dates (Table 3-12). As already mentioned, the first four of these species are ubiquitous in the Chesapeake Bay, and Wass (1967) feels that they are tolerant of adverse physical conditions. Thus, the general data present on the first four species is in agreement with expected results.

There are several species that were absent in the March sampling but which appeared occasionally in August (Table 3-14). These species are the clam Rangia cuneata, two isopods (Cyathura polita and Edotea triloba), and worms of the class Nematoda. The presence of these organisms during August may represent a seasonal change in the species composition of the area, or it is also likely that some absences of species in March might represent sampling error; low densities may have prevented their collection by the benthic grab device described above. With the exception of the Nematodes, all of these species have been reported by Pfitzenmeyer (1971) and Hamilton (1972) in or near the Patapsco River estuary in the same relative numbers.

The abundance of the polychaete worm Scolecopides viridis declined most drastically from March to August at all sampling sites (Fig. 3-18). This worm is an infaunal form (living in the sediments) which moves horizontally and vertically in the sediment layers and feeds on organic detritus. The worm would be vulnerable to heavy sedimentation, as occurred during hurricane Agnes, and to predation by the carnivorous polychaete Nereis succinea. Scolecopides viridis has not been found as particularly tolerant or intolerant of any particular conditions, but such is not the case for Nereis succinea. Wass

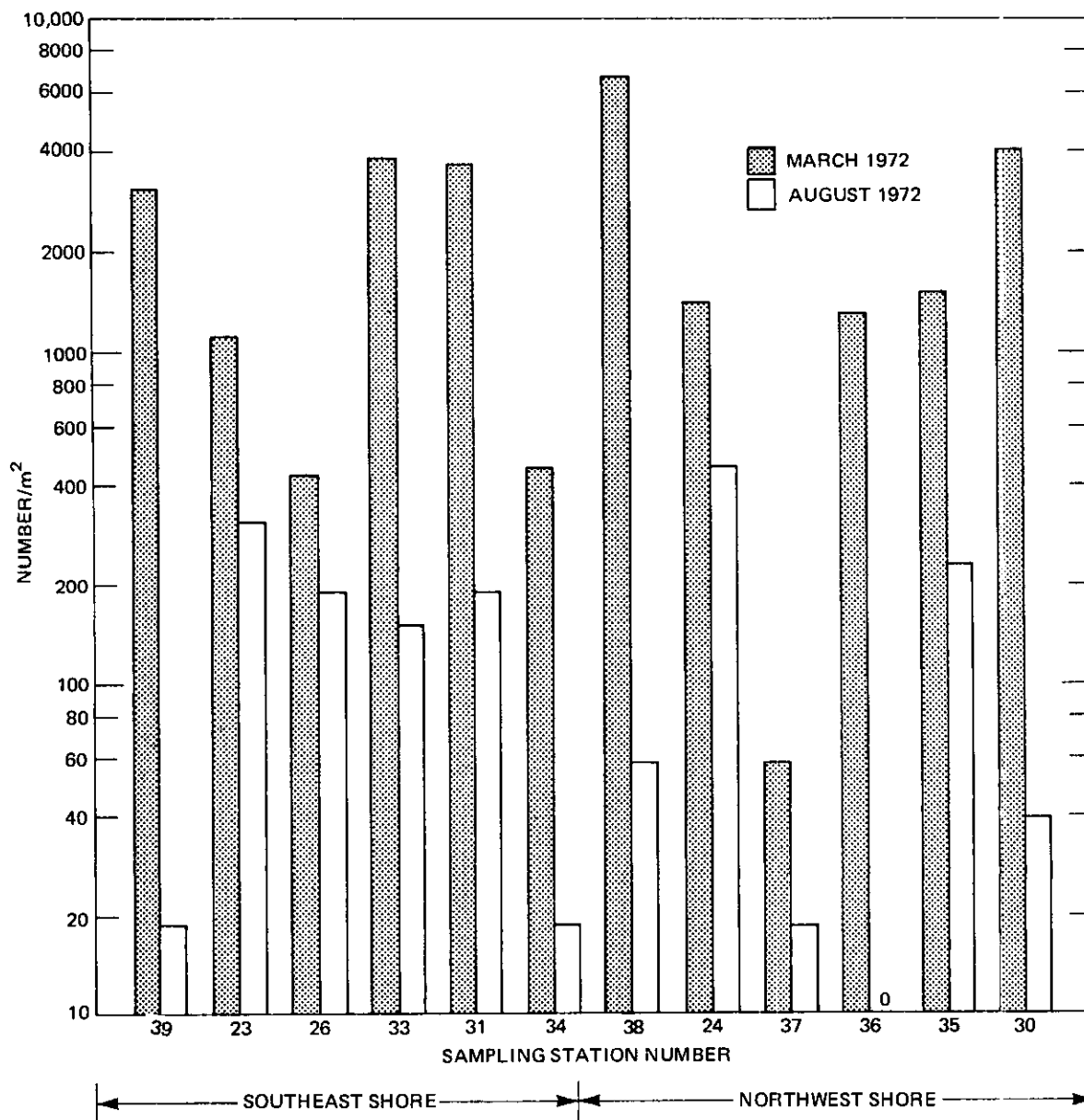


Figure 3-18 NUMBER OF *Scolocolepides viridis* PER SQUARE METER, PATAPSCO RIVER ESTUARY.

(1967) and Hamilton (1972) both identify Nereis succinea with regions of low productivity, low species diversity, and adverse conditions. The species has shown sharp changes in abundance only at Stations 32 and 34; the changes remain unexplained (Fig. 3-19 and Table 3-12).

The amphipod Leptocheirus plumulosus has shown an expected increase in abundance at most stations. The summer months are the peak months in the reproductive cycle and it was noted that many small amphipods were found, supporting the hypothesis that the increase is a seasonal one (Fig. 3-20).

The changes in both the distribution and the abundance of the tubificid worms is semi-infaunal, it may have been affected by the sediment load from hurricane Agnes. In addition, the migration of blue crabs up the estuary following the hurricane may have increased the predation upon the tubificids (Fig. 3-21).

The only species of gastropod found was the Pyramidillid Odostomia sp. which is reported to be an ectoparasite on bivalves and polychaetes (Fretter and Graham, 1949). Sanders (1960) found a pyramidillid gastropod in Buzzard's Bay, but was unable to associate it with any particular host species. He suggested that the gastropod is a deposit feeder, and it is suspected that the same is true for Odostomia sp. The only significant change in distribution occurred at Station 23 which may be a result of local migration (Fig. 3-22).

The brackish-water clam Rangia cuneata was found in the Potomac River estuary (Pfitzenmeyer and Drobeck, 1964) and in very high densities in the Bush River estuary (current research). One possible explanation for the almost complete absence of the species in the Patapsco River estuary may be unfavorable characteristics of the sediments or water. Tenore et al. (1968) found that silt-

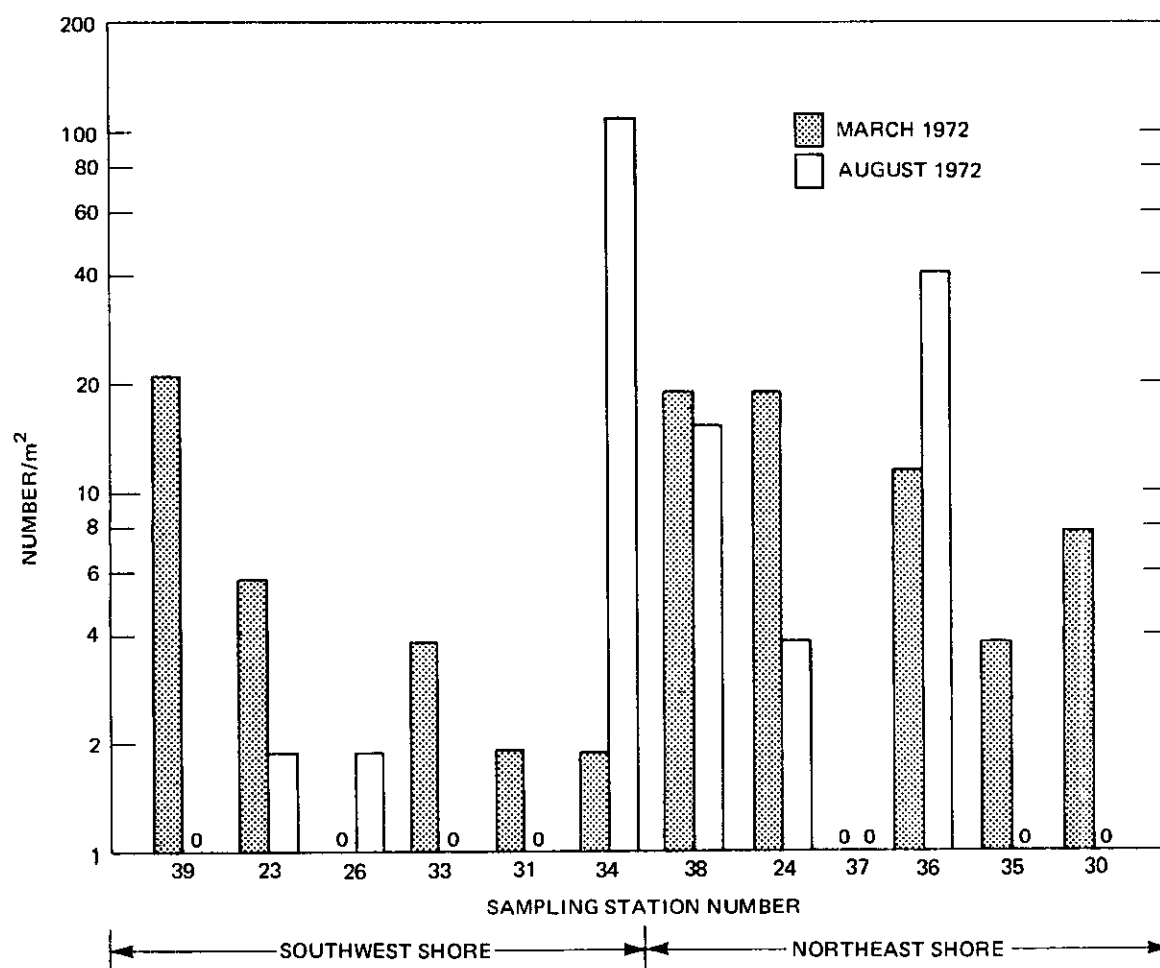


Figure 3-19 NUMBER OF *Nereis succinea* PER SQUARE METER, PATAPSCO RIVER ESTUARY.

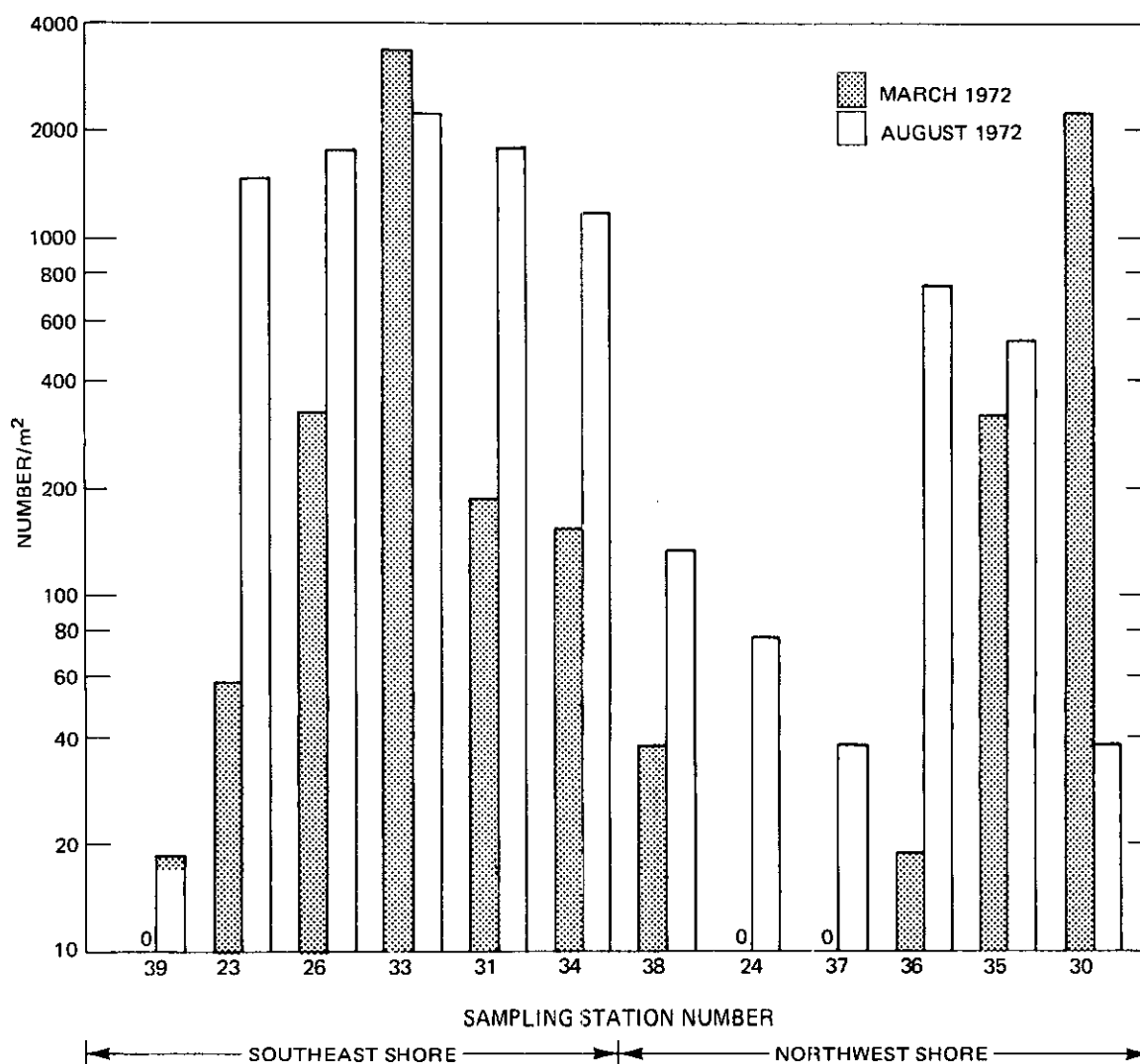


Figure 3-20 NUMBER OF *Leptocheirus plumulosus* PER SQUARE METER, PATAPSCO RIVER ESTUARY.

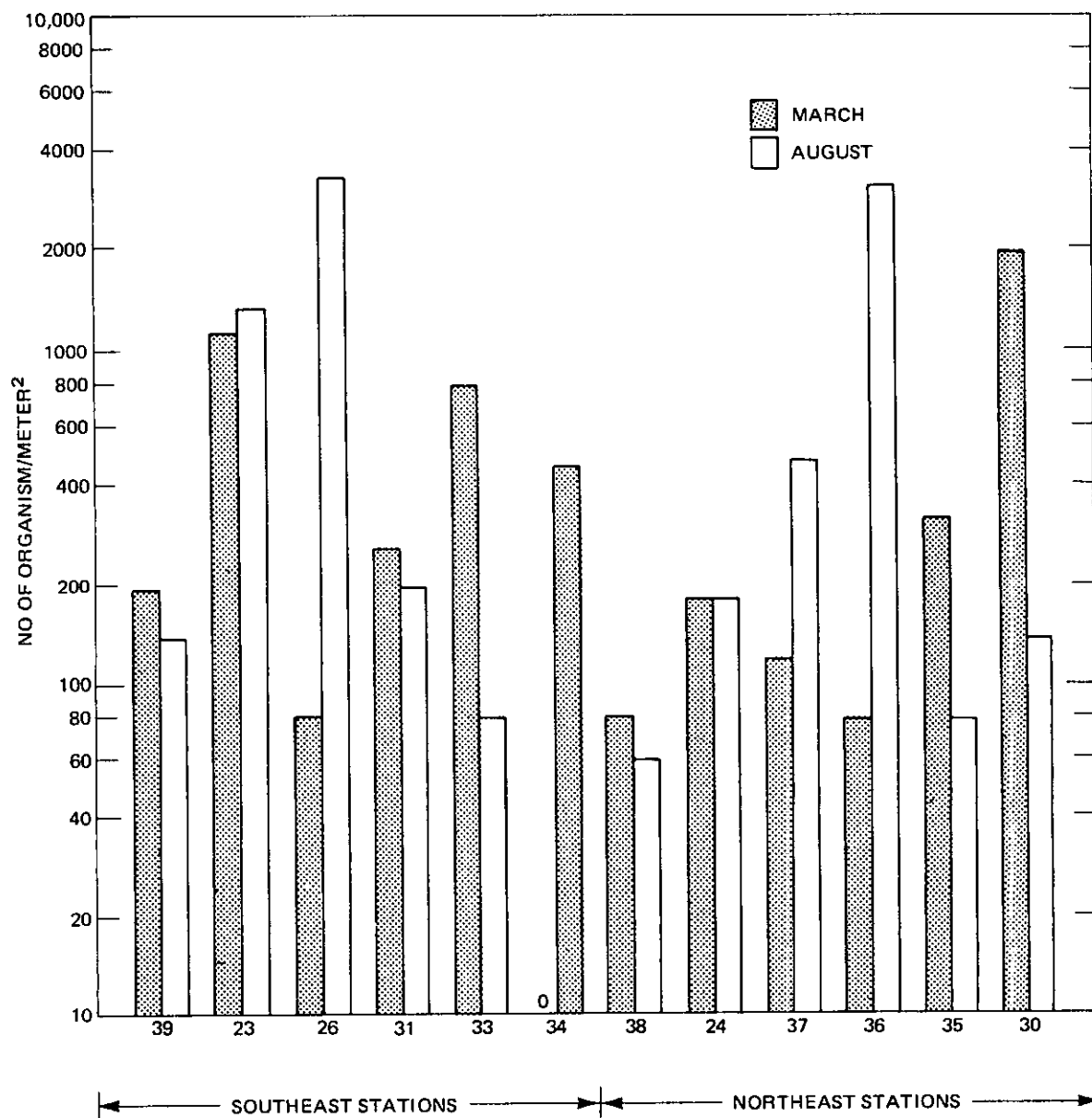


Figure 3-21 NUMBER OF TUBIFICIDAE PER SQUARE METER, PATAPSCO RIVER ESTUARY.

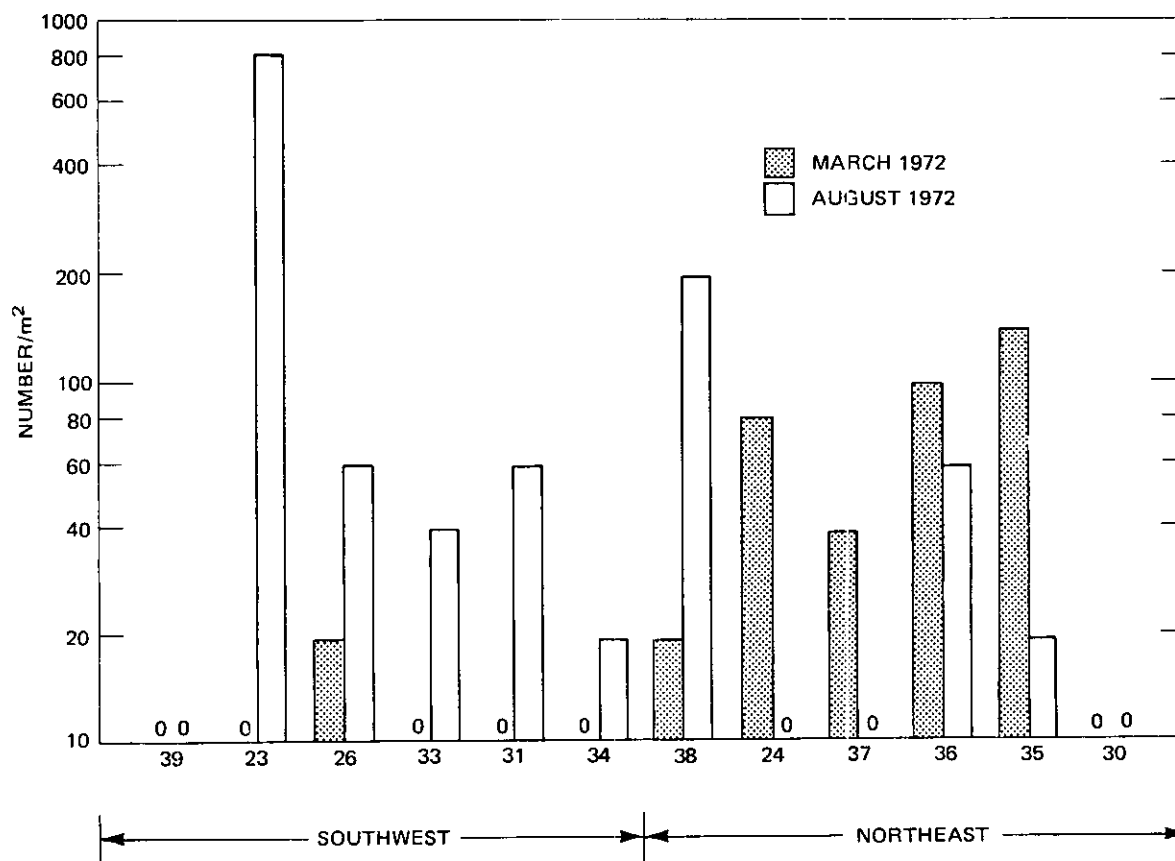


Figure 3-22 NUMBER OF *Odostomia* SP. PER SQUARE METER, PATAPSCO RIVER ESTUARY.

clay sediments were an unfavorable substrate and that the species grew best in a sandy substrate which had a high phosphate and organic content.

The polychaete Heteromastus filiformis was the major species of worm in the estuary, as shown by preliminary studies in 1971. This work is a tube-dwelling, detrital feeder which was found by Wass (1967) to be a species which is tolerant of adverse physical conditions. Despite its tolerance, the numbers of H. filiformis have decreased significantly through August. There does not seem to be any obvious explanation for the decline though predation by Nereis succinea and Callinectes sapidus or sedimentation during hurricane Agnes may have contributed.

Although the number of species found thus far has increased from March to August (Table 3-14) and from 1971 to 1972, Pfitzenmeyer found a greater number of species during 1970. It is obvious, however, that no major taxonomic group has been eliminated from or added to the benthic biota of the Patapsco River estuary. Biomass values obtained in August (Tables 3-12 and 3-14) compare well with those found by Pfitzenmeyer in the Patapsco, but are about ten times lower than the values which he found on the Chester River. Such indicators of the species composition indicate that the benthic biota is not lacking any major taxonomic groups expected and that the relative abundance of the species changes seasonally. Differences found between sampling sites on the Patapsco River estuary seem to be due primarily to substrate differences rather than local cultural influences. It is probable, however, that the sediments are capable of supporting a more abundant and diverse species assemblage than presently found (Fig. 3-23).

Fish and Ichthyoplankton

Methods and Materials. Several methods of fish collection are being employed to sample monthly all of the various fin-fish species at the different life stages and habitats present in the lower Patapsco River estuary.

PATAPSCO RIVER ESTUARY SPECIES ABUNDANCE IN ORGANISMS/METER²

SOUTHWESTERN STATIONS												NORTHEASTERN STATIONS												
ORGANISM	39		23		26		33		31		34		38		24		37		36		35		30	
	MAR	AUG	MAR	AUG	MAR	AUG	MAR	AUG	MAR	AUG	MAR	AUG	MAR	AUG	MAR	AUG	MAR	AUG	MAR	AUG	MAR	AUG	MAR	AUG
<u>Tubificidae</u>	190	136	1104	1377	329	2309	251	194	774	72	0	446	77	58	175	175	116	465	77	3240	309	78	1917	136
<u>Scolecoides viridis</u>	3099	19	1414	310	426	194	3796	155	3622	194	484	19	6702	58	1375	446	58	19	1136	0	1510	233	4067	39
<u>Leptocheirus plumulosus</u>	0	19	58	1494	329	1785	3390	2289	190	1084	154	1183	38	136	0	78	0	39	19	757	329	543	2285	39
<u>Nereis succinea</u>	213	0	58	19	0	19	38	0	19	0	19	1086	190	155	190	39	0	0	116	407	38	58	77	0
<u>Odostomia</u> sp.	0	0	0	795	19	58	0	39	0	58	0	19	19	194	77	0	38	0	96	58	135	19	0	0
<u>Macoma balthica</u>	0	0	0	0	19	19	18	0	368	0	136	136	19	291	0	0	0	0	0	19	38	0	116	0
<u>Heteromastus filiformis</u>	0	0	0	0	0	116	213	0	0	0	0	19	96	0	232	19	38	0	0	0	77	19	213	0
<u>Rangia cuneata</u>	0	0	0	19	0	116	0	0	0	58	0	19	0	0	0	19	0	0	0	0	0	155	0	58
<u>Cyathura polita</u>	0	0	0	19	0	39	0	175	0	19	0	136	0	0	116	194	0	0	0	0	0	116	0	136
<u>Edotea triloba</u>	0	0	0	0	0	0	0	19	0	19	0	39	0	0	0	0	0	0	0	0	0	0	0	19
Nematoda	0	0	0	0	0	58	0	563	0	5741	0	0	0	0	0	78	0	0	0	0	0	0	0	0
<u>Hypania gravi</u>	0	0	0	19	0	19	19	58	0	0	0	0	0	0	542	834	0	0	0	0	0	58	0	0
<u>Carinoma tremephoros</u>	0	0	0	50	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<u>Corophium lacustre</u>	0	0	0	0	0	0	0	0	0	0	0	97	0	0	38	39	0	0	0	0	0	0	0	1571
Chironomidae	0	0	0	19	38	0	0	213	0	0	0	19	0	0	0	0	0	0	0	0	0	0	0	0
<u>Mulinia lateralis</u>	0	0	0	0	0	0	19	0	19	0	0	0	0	0	116	0	0	0	0	0	0	0	0	0
Copepoda	0	0	0	0	0	0	0	797	0	272	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<u>Streblospio benedicti</u>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	406	0	0	0
TOTAL NO. SPECIES	5	3	4	10	6	12	9	10	7	9	5	13	7	6	10	10	4	3	5	6	9	9	8	7

NOTE: Organisms are listed in order of occurrence. This list does not include 5 species that occurred once in one grab during the sampling dates. However, these data were used in determining the total number of species.

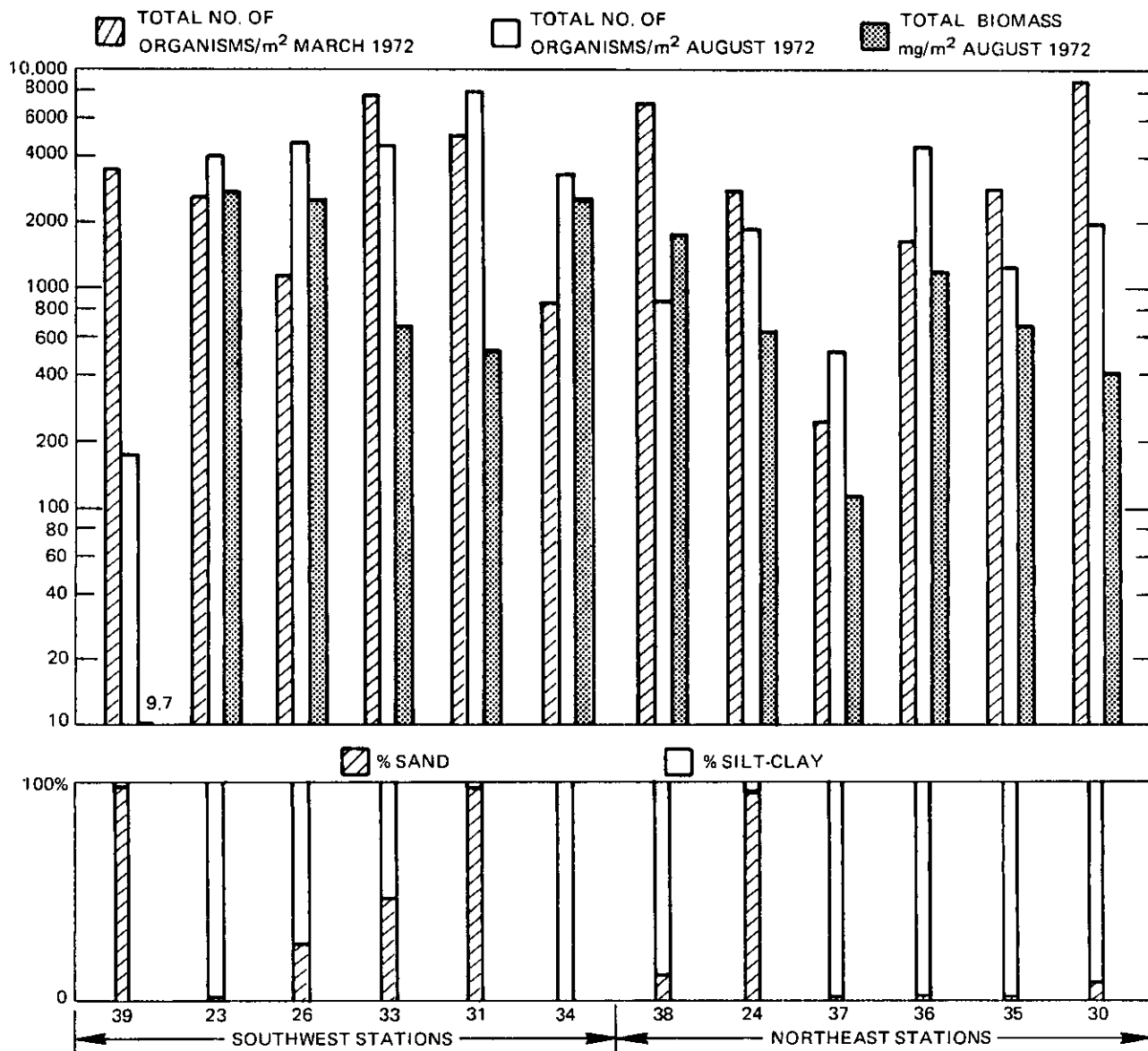


Figure 3-23 TOTAL NUMBER OF BENTHIC INVERTEBRATES, BIOMASS AND SEDIMENT COMPOSITION FOR SAMPLING STATIONS IN THE PATAPSCO RIVER ESTUARY.

Mechanical difficulties on the R/V Acartia forced postponement of the July sampling from the planned 24 through 26 July to 31 Jul and 1 and 2 Aug. Otherwise the normal established sampling schedule was followed.

Fish egg and larval populations are sampled by means of a 0.5-meter diameter plankton net mounted on a steel frame sled towed for 15 minutes (as described previously for zooplankton populations). Fish eggs and larvae collected are preserved in 4% formalin and identified to the species level where possible or feasible, and the specimens are then stored at The Johns Hopkins University for reference. Egg diameters and total lengths of larvae in millimeters are measured and recorded, and the latter will be used to establish length frequencies and growth curves with succeeding sampling dates.

A 50 by 6 foot beach seine is used to sample the resident fishes inhabiting the shore zone, young-of-the-year, and juveniles of fishes spawned in the area or using the area as a nursery ground. The beach seine employed has 3/4-inch stretch (3/8-inch bar) mesh in the wings and 1/2-inch stretch (1/4-inch bar) mesh in the bag. Beach seining is of necessity limited to rather smooth, clean areas of less than a 6-foot depth and must be landed on a gently sloping beach surface to prevent fishes from escaping under the lead line. Seining is regularly performed at each of six stations in the Patapsco River (Stations 22, 23, 26, 27, 29, and 32 on Fig. 3-5). Fishes collected by beach seine are identified to species and the total lengths (in mm) of a representative number of specimens of a species (30 or 40) are recorded. The remaining specimens of a species are counted and then recorded. This allows most fish to be released alive. However, rare species or unusual specimens are preserved for reference purposes.

Two types of trawls are used to sample the adult fishes. A 16-foot semi-balloon, or otter trawl, with 1-1/2-inch stretch mesh in the body, and a 1-1/4-inch stretch mesh in the cod end with a 1/2-inch stretch mesh inner

liner is employed to catch bottom-dwelling and epi-benthic fishes such as hogchokers, catfish, eels, and white perch. D-traps were utilized in the preliminary study (July-August, 1971) to catch these bottom dwelling and epi-benthic species, but use was discontinued in favor of the otter trawl with its higher catch rates. A 10 by 10 foot modified Cobb pelagic or midwater trawl of 3/4-inch stretch mesh in the body and 1/2-inch stretch mesh in the cod end is used to sample the fishes that inhabit the upper portions of the water column. These fishes are typified by the anchovy, herrings, menhaden, and other forage species. All trawls are of 10 minute duration. Both types of trawls are used at each of the six stations in the Patapsco River (Stations 20, 21, 24, 25, 30, and 31 on Fig. 3-5). Fishes collected by both methods of trawling are identified to species with a representative number measured and the remainder counted and released as with the seined specimens. Occasionally, stomach contents are analyzed and conditions of gonads noted where pertinent. A routine comprehensive stomach analysis will be performed on several species later in the present study.

Ultimately, fisheries data will be punched onto computer cards for more complete and rapid analysis. Such items to be examined include species composition at each station; percentage composition of the species population contributed by each year class; species distribution as affected by water temperatures and dissolved oxygen concentrations; and species diversity at each station and at a particular station over a time interval, reflecting temperature, salinity, or DO preference changes, or changing behavior patterns of the life cycle.

Review of Literature. Fisheries research in the Patapsco River and adjacent waters of the upper Chesapeake Bay have been reported only fairly recently. The Chesapeake Biological Laboratory conducted a general biological survey of the Patapsco River with specific

reference to Baltimore Harbor in 1970-71. Fish egg and larvae samples were collected at 12 stations in the Patapsco River and major tributaries and beach seining was carried out at 17 stations during the sampling period of one year starting in March 1970 (Dovel, 1971a).

Fish egg and larvae sampling results indicated that in general the lower portions of the Patapsco River system are reasonably clean by water pollution standards and contrast sharply with the uppermost portions, specifically, the inner harbor and the mid-section of Curtis Creek. Although no eggs of such spring-time spawners as the herrings of the genus Alosa, white perch, or striped bass were found, the larvae of these species were found. This indicates that even though there may be no spawning in the areas sampled, there may be spawning outside the area, either up- or down-stream, and the larvae are able to utilize the waters of the sampling area for nursery purposes. Eggs of the summer-spawning bay anchovy and hogchoker were found in fairly good numbers in the lower stations, suggesting that this portion of the tributary is used as a spawning ground. Dovel points out that there were no hogchoker larvae found in the entire system, and attributes this scarcity to a somewhat degraded epibenthic habitat which is unsatisfactory for development of larval hogchokers. Contrasted with this is the presence of anchovy larvae throughout the system — a fact that suggests the water column itself is reasonably clean and quite able to support developing larval anchovies, though the bottom sediments do not appear to support either the hogchoker or the bottom-dwelling juvenile croaker, also absent from the fish egg and larvae samples. Other larval species found in the Patapsco River include: herrings, naked gobies, and silversides, all of which are found up in the water column rather than closely associated with the bottom. Mention is made of the presence of juvenile menhaden although no specific data from beach seining is presented.

Adult fish distributions are described by Wiley (1971) in the above-mentioned biological study of Baltimore Harbor. Of particular interest is the apparent contradiction in the near total absence of bottom fishes (especially as compared to similar trawl stations in the nearby Chester River) and the very large numbers of white perch, a fish that is somewhat eip-benthic in its habitat. As with the fish larvae distributions, the lowermost stations yielded decidedly more species and more fish than the upper stations, suggesting again the improved water quality and bottom conditions as one moves downstream from inner harbor toward the bay. Three species (striped blenny, naked goby, and winter flounder) were found in the Chester River and not in the harbor at all, and two other species (oyster toadfish and hogchoker) were caught only rarely and once, respectively, in the harbor, yet were common in the Chester River. All five are bottom species. Wiley feels that low DO values and bottom sediments that are composed largely of an oily sludge are responsible for this difference in the populations of bottom-dwelling fishes.

White perch was the most dominant species in both the harbor and in the Chester River control area. Wiley (1971) pointed out some differences in the age class composition of the two rivers citing the absence of young-of-the-year white perch from the Chester River stations in the period 6 July through 1 September. However, less frequent sampling between those dates (less than half as many stations as normally sampled), a disproportionate amount of sampling in the mouth, and almost no samples taken above mile 3 of the Chester River may have accounted for these results. Also noted was the higher incidence of infection of the lateralis system and deterioration of fin tissues in Baltimore Harbor over Chester River white perch, possibly a result of pollution stresses. In 1971 ichthyoplankton tows and seine hauls were made at several stations in the vicinity of the Herbert A. Wagner Plant of the Baltimore Gas and Electric Company on two dates: 16 Jul 71 and 31 Aug 71. This preliminary sampling effort

was part of a consultants report (BioCon, 1971) to the Baltimore Gas and Electric Company and the data collected will be referred to in the discussion section.

Recent fisheries research was conducted in the upper Chesapeake Bay with specific regard for the effects of overboard disposal of ship channel dredging spoil. Bi-weekly sampling of fish eggs and larvae (by ichthyoplankton net tows) and adults (by otter trawl tows) in the upper bay during the period May 1966 to November 1968 yielded vast amounts of basic, background information on the nature and status of the fisheries populations of the upper bay (Dovel, 1970; Ritchie, 1970). In the fish egg and larvae studies Dovel groups the fishes into freshwater, estuarine, and marine spawners and describes the general life habits of each of the three, giving examples of each. He also stresses the importance of the upper bay from Poole's Island northward to Turkey Point as a nursery ground upon which depends the successful survival of many species of fish. This area of low salinity (0 to 11 ppt) is heavily used all or in part during virtually the entire year by one or more species as a spawning and/or nursery area for some 13 species of freshwater-spawners, 13 species of estuarine-spawners, and 11 species of marine-spawners (Dovel, 1970).

Research on adult fishes of the upper Chesapeake Bay has been conducted as part of an effort made to ascertain the effects of dredge spoil disposal. Ritchie (1970) reported that 44 species of fish - 13 freshwater and 31 marine forms - were captured by trawling at 10 stations on 5 transects running perpendicular to the shipping channel in the upper bay. The fishes were described as year-round residents (striped bass, white percy, channel catfish, hogchoker, yellow perch, alewife, bay anchovy and blueback herring), seasonal migrants (spot, weakfish, silver perch, and bluefish), and irregular visitors (silver hake and northern sea robin).

White perch were the most abundant during most months, but also present in large numbers were striped bass, anchovy, channel catfish, hogchokers, and gizzard shad. On the basis of the trawl data, the upper Chesapeake Bay from Turkey Point south to Poole's Island shows a large diversity of fish species using the area, some as year-round residents and some as seasonal visitors either as part of a spawning migration or merely entering during the warm-water periods for feeding purposes. The most upstream stations — those with the lowest salinities — showed the greatest species diversity; the seasonal changes (water temperature and salinity) and not sampling depth appeared to have the greatest effect on the species composition in the samples.

Dovel (1971b) has also summarized 10 years of fish egg and larvae sampling in the upper Chesapeake Bay, Magothy River, and Patuxent River, stressing the similarity of the freshwater/brackish-water interface areas of each of these somewhat separated regions of the Chesapeake Bay system. This area in each separate sampling region appears to be quite important as a spawning area (for white perch, striped bass, and herrings — genus Alosa) as a nursery area for fishes that have spawned in freshwater (yellow perch) or brackish water (anchovy, hogchoker, naked goby, winter flounder) or in the marine environment (menhaden, croaker, spot, and bluefish). This area also supports the resident forage species such as the top minnows (genus Fundulus) and the silversides (genus Menidia) which, in addition to the young of other species, provide a great bulk of the food for the game and commercially important species, most notably bluefish and striped bass (Dovel, 1971b).

Dovel notes also the greatest densities of zooplankton in the Patuxent to be coincidental in time and location with the developing larvae of the freshwater spawners and feels this is significant in the transition of the larvae from yolk-sac absorption to active feeding. The estuarine spawners such as the hogchoker and anchovy do so over a

rather large area of the estuaries and under a wide range of temperatures and salinities. Eggs of the anchovy in the Patuxent River (1963) were found, for instance, at salinities ranging from 3 to 23 ppt, and the larvae after moving toward fresher water were found between salinities of 0 and 21 ppt (Dovel, 1971b). Likewise, the marine spawners by virtue of the migration to fresher water as larvae encounter and obviously tolerate large salinity and temperature changes. However, the presence of larvae and/or juvenile of all three groups of spawners in the low saline areas (1 to 15 ppt salinity) indicates the great importance of this area for normal growth and development of each of the species.

Although Dovel (1971b) feels that salinity is the dominating factor in the distribution of eggs and larvae in the upper bay systems, temperature is certainly quite essential in determining the proper development of gonadal tissues and spawning behavior in adults, and proper development of the embryo and the resultant larvae. Of interest is the fact that larvae or juveniles of several estuarine-dependent species often over-winter in the very cold waters of the upper estuary, though the warmer, deeper waters further downstream are relatively close by.

In general summation of the present status of fisheries research, the Chesapeake Bay seems to be a rather typical example of a coastal plain estuary. There is a rather diverse fisheries population structure composed of at least 44 species, as sampled by trawling; and, in addition, the upper estuary provides a spawning and/or nursery area for many fishes. The Patapsco River and Baltimore Harbor immediately adjacent to this upper bay area have many of the species found in the larger body of water; however, a freshwater inflow that is very small in comparison to that of the Susquehanna River and the heavy domestic and industrial pollution input have reduced numbers of species utilizing the Patapsco River system. It should be mentioned, however, that prior work has indicated that several species, most notably the white perch,

are found in large numbers during most of the year in the lower Patapsco River. Other fishes such as the menhaden and Norfolk spot appear to come into the Patapsco in large numbers during the warm months to feed and grow. Certain areas of the Patapsco River, because of bottom conditions or pollution input, are definitely not supporting large numbers of any species of fish. However, other areas further toward the bay are heavily utilized by the same species that are found in other similar, but perhaps unpolluted, tributaries of the upper Chesapeake Bay. In short, the number and diversity of species of fishes found in the cleaner areas of the Patapsco River indicate that this tributary is reasonably healthy and contributes much to the fisheries ecology of the upper Chesapeake Bay.

Results. Fish sampling in the Patapsco River during the period March through August 1972 using all gear types yielded a total of 7922 fishes of 24 species represented by eggs, larvae, juveniles, and adults (Table 3-15). Ichthyoplankton tows at seven stations over this 6-month period produced a total of five Alosa sp. eggs and 124 larvae comprising five species. In some cases the larval specimens were badly damaged, making identification possible only to the family level. A summary of the egg and larvae results are presented in Table 3-16. A total of 1941 fish of twenty-two species were collected with the beach seine from May to August 1972 at six stations during four sampling periods. The data from these 24 samples has been summarized in Figs. 3-24 through 3-27 and Table 3-17.

The relative abundance figures given in Tables 3-17 to 3-19 are given to present a more reliable estimate of actual numbers. Many of these are schooling fish; thus, sampling figures can be either extremely high or low. Converting the total numbers to relative-abundance figures shows the catch per unit effort. This will diminish the extremes, such as the menhaden figures in Figs. 3-24 through 3-27 and Table 3-17. Figures 3-24 through 3-27 present

TABLE 3-15

SCIENTIFIC AND COMMON NAMES OF FISHES, EGG, LARVAE,
JUVENILE AND ADULT FORMS COLLECTED FROM THE PATAPSCO
RIVER, MARCH—AUGUST, 1972

Scientific name, common name	Egg	Larvae	Juvenile	Adult
Clupeidae				
<u>Alosa aestivalis</u> , blueback herring				X
<u>Alosa</u> sp.	X	X		X
<u>Brevoortia tyrannus</u> , menhaden		X	X	X
<u>Dorosoma cepedianum</u> , gizzard shad				X
Engraulidae				
<u>Anchoa mitchilli</u> , bay anchovy		X	X	X
Cyprinidae				
<u>Notemigonus crysoleucas</u> , golden shiner				X
<u>Notropis hudsonius</u> , spottail shiner				X
<u>Notropis</u> sp.			X	X
Ictaluridae				
<u>Ictalurus nebulosus</u> , brown bullhead				X
Anguillidae				
<u>Anguilla rostrata</u> , American eel				X
Belonidae				
<u>Strongylura marina</u> , needlefish				X
Cyprinodontidae				
<u>Fundulus heteroclitus</u> , mummichog				X
<u>Fundulus majalis</u> , striped killifish				X
Serranidae				
<u>Morone americanus</u> white perch		X	X	X
<u>Morone saxatilis</u> , striped bass				X
Centrarchidae				
<u>Lepomis gibbosus</u> , pumpkinseed				X
Percidae				
<u>Perca flavescens</u> , yellow perch				X
Pomatomidae				
<u>Pomatomus saltatrix</u> , bluefish			X	

TABLE 3-15 CONTINUED

Scientific name, common name	Egg	Larvae	Juvenile	Adult
Scianidae				
<u>Leiostomus xanthurus</u> , Norfolk spot			X	
<u>Micropogon undulatus</u> , Atlantic croaker			X	
Gobiidae				
<u>Gobiosoma boscii</u> , naked goby		X		
Atherinidae				
<u>Menidia beryllina</u> , tidewater silverside		X		X
<u>Menidia menidia</u> , Atlantic silverside				X
Soleidae				
<u>Trinectes maculatus</u> , hogchoker				X

TABLE 3-16
PATAPSCO RIVER MARCH-AUGUST ICHTHYOPLANKTON TOW SAMPLE DATA

Sampled	20	21	24	25	28	30	31
March	not sampled	sampled twice none	none	<u>B. tyrannus</u> 38.0	not sampled	none	none
April	NONE	none	none	<u>G. bosci</u> 18.0	not sampled	none	<u>B. tyrannus</u> 22-35, 29.67 (3) <u>Alosa sp.*</u> 0.8-1.5, 1.1(5)
May	<u>Alosa sp.</u> 6.2	none	none	none	none	<u>Alosa sp.</u> 7.4-7.9, 7.65(2)	none
June	<u>M. beryllina</u> 6.4-12.4, 10.25(4)	<u>M. beryllina</u> 5.8-10.1, 7.95(2)	<u>M. beryllina</u> 5.9-10.3, 7.10(4)	<u>M. beryllina</u> 5.1-13.3, 10.06(5)	<u>M. beryllina</u> 5.0	<u>M. americanus</u> 4.0	<u>M. americanus</u> 4.2-4.9, 4.55(2) <u>Alosa sp.</u> 9.4(1) <u>M. beryllina</u> 14.3
July	<u>G. bosci</u> 3.7-5.8, 4.93(7)	<u>G. bosci</u> 4.6-10.6, 7.13(27)	<u>G. bosci</u> 5.1-5.2, 5.15(2)	<u>Alosa sp.</u> 4.1	<u>G. bosci</u> 13.4	<u>G. bosci</u> 3.0-7.7, 4.39(13) <u>Alosa sp.</u> 5.7 <u>A. mitchilli</u> 8.0	<u>G. bosci</u> 3.3-4.8, 4.17(3)
August	<u>G. bosci</u> 7.7-12.0, 11.42(9)	<u>G. bosci</u> 9.0-11.3, 10.38(4) <u>M. beryllina</u> 5.2	<u>G. bosci</u> 5.2	<u>G. bosci</u> 6.7-10.6, 8.5(5) <u>A. mitchilli</u> 9.6	<u>G. bosci</u> 6.2-9.2, 7.7(2) <u>A. mitchilli</u> 11.0-11.1, 11.05(2)	<u>G. bosci</u> 8.0-9.0, 8.5(2) <u>A. mitchilli</u> 8.0	<u>G. bosci</u> 4.8-10.0, 7.55(10) <u>M. beryllina</u> 9.9

* All of the species listed above are larvae unless noted by an asterisk (*) representing eggs.
The numerals below the species denote range, mean and (total number), respectively.
If only one specimen, just the length is given

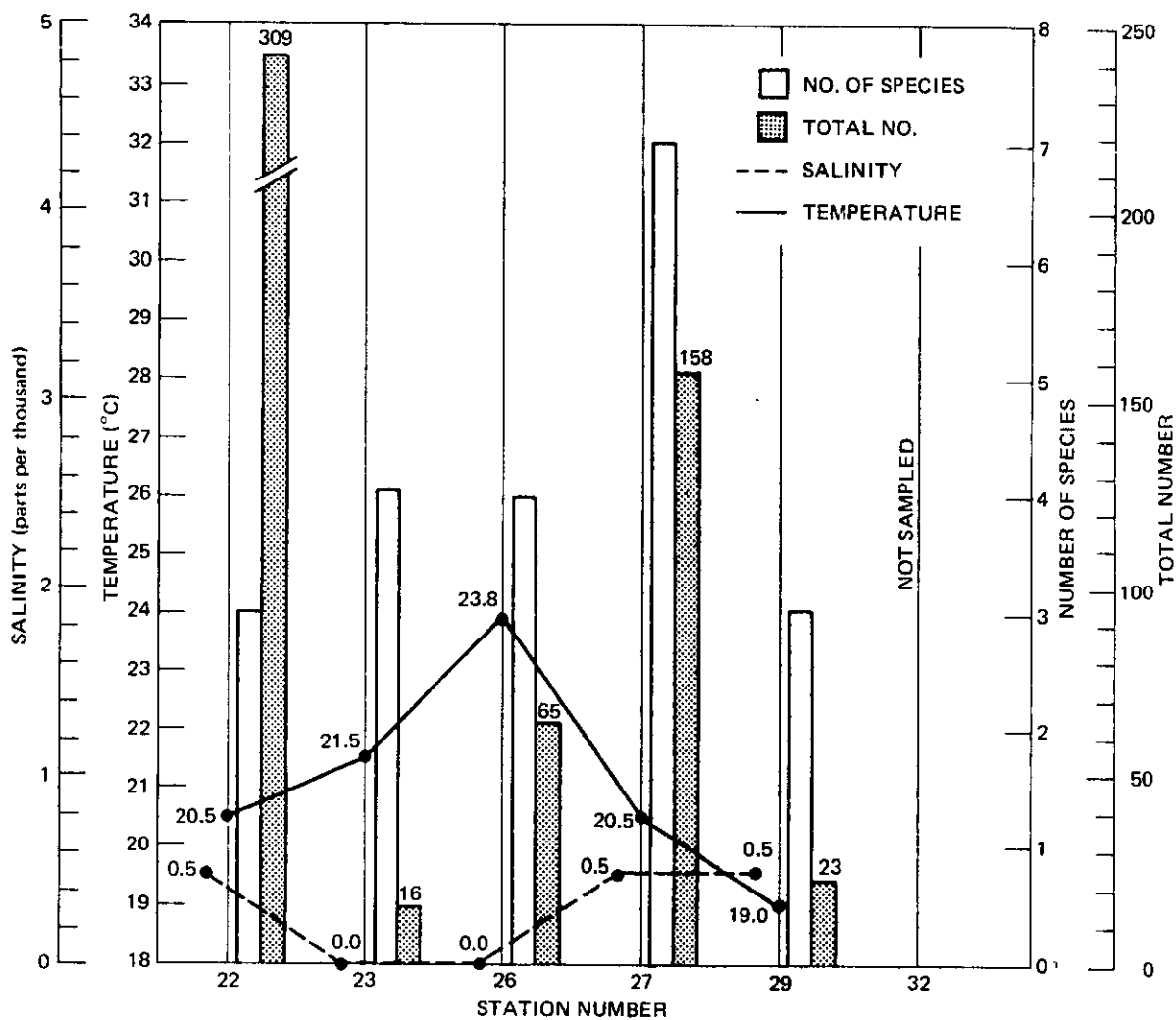


Figure 3-24 WATER TEMPERATURE, SALINITY, NUMBER OF SPECIES, AND TOTAL NUMBER OF FISH COLLECTED BY BEACH SEINE IN PATAPSCO RIVER ESTUARY DURING MAY 1972 SAMPLING.

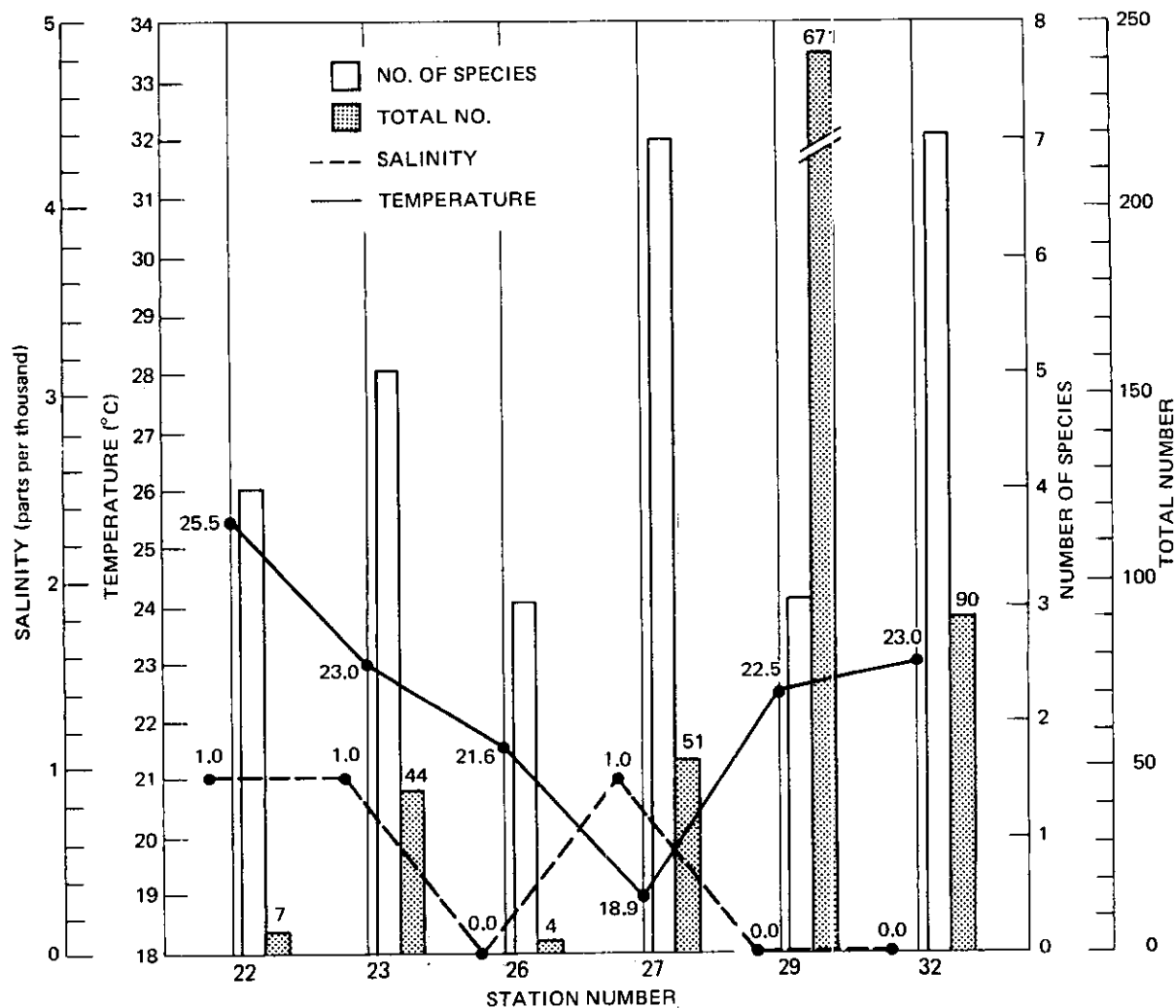


Figure 3-25 WATER TEMPERATURE, SALINITY, NUMBER OF SPECIES, AND TOTAL NUMBER OF FISH COLLECTED BY BEACH SEINE IN PATAPSCO RIVER ESTUARY DURING JUNE 1972 SAMPLING.

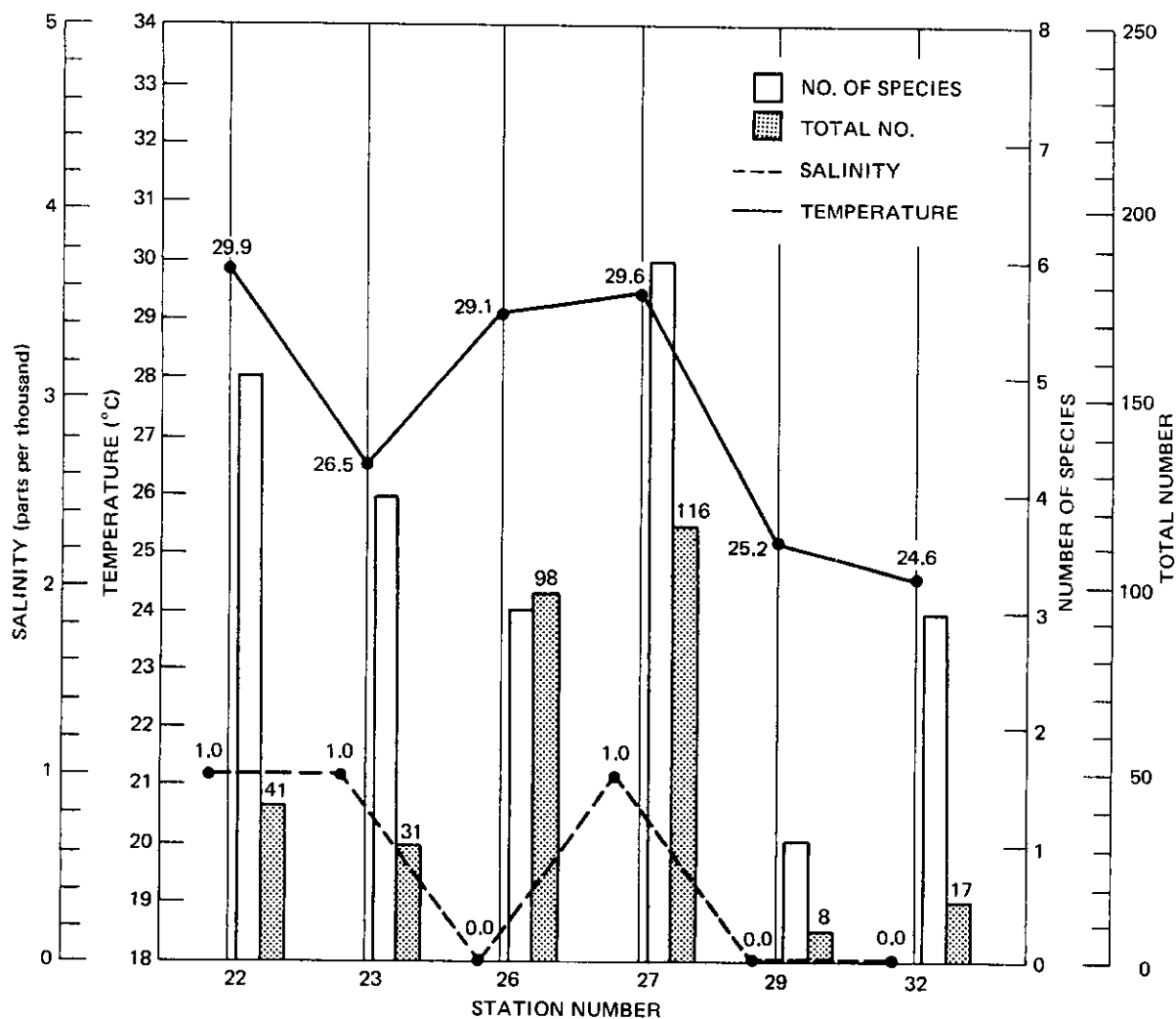


Figure 3-26 WATER TEMPERATURE, SALINITY, NUMBER OF SPECIES, AND TOTAL NUMBER OF FISH COLLECTED BY BEACH SEINE IN PATAPSCO RIVER ESTUARY DURING JULY 1972 SAMPLING.

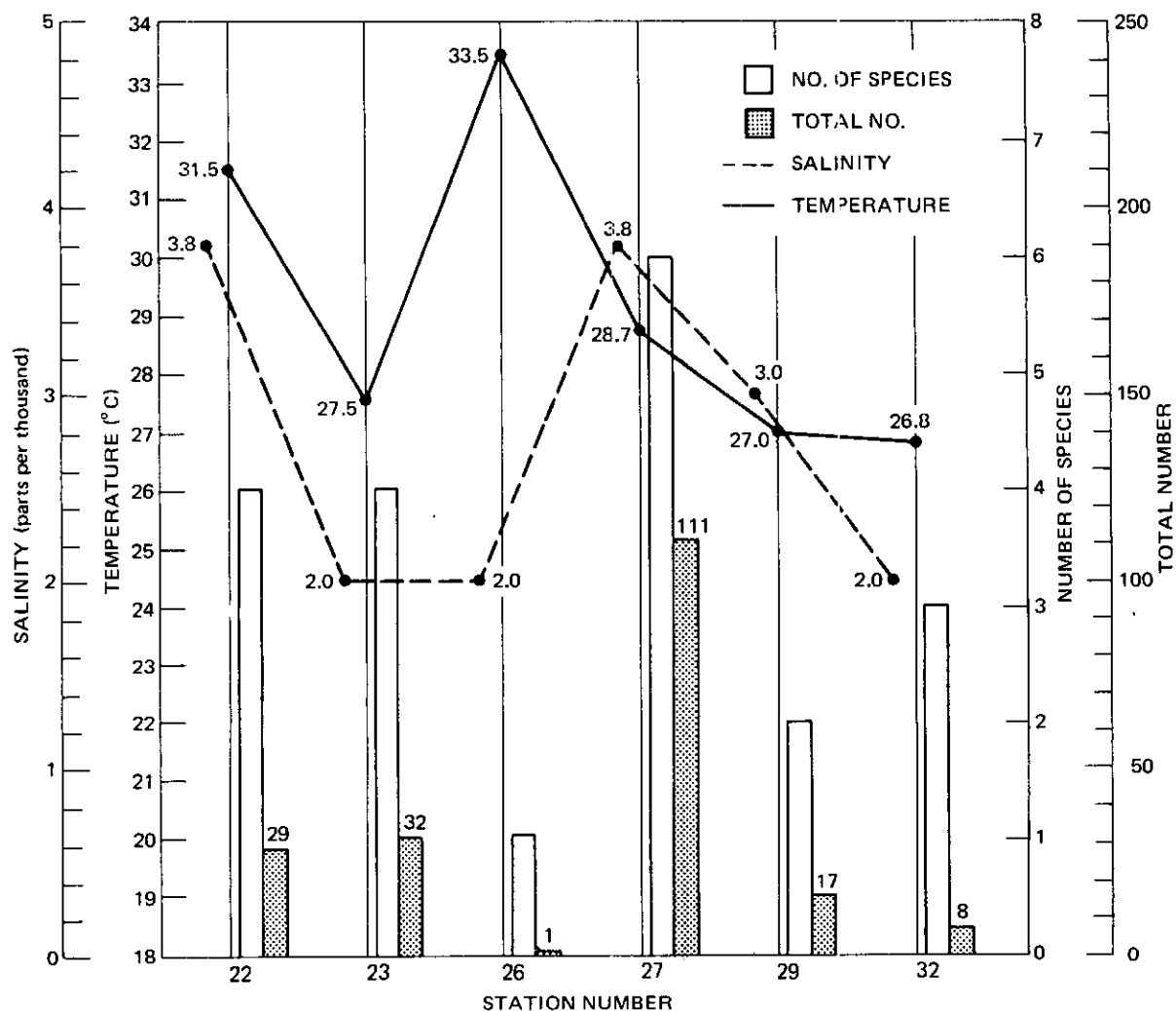


Figure 3-27 WATER TEMPERATURE SALINITY, NUMBER OF SPECIES, AND TOTAL NUMBER OF FISH COLLECTED BY BEACH SEINE IN PATAPSCO RIVER ESTUARY DURING AUGUST 1972 SAMPLING.

TABLE 3-17

TOTAL NUMBERS, NUMBERS OF OCCURRENCES, AND RELATIVE ABUNDANCE OF FISH
IN 23 SEINED SAMPLES FROM THE PATAPSCO RIVER AT 6 STATIONS

Fish	Total	Occurrence	Relative* Abundance
Tidewater silverside	762	21	693.42
Menhaden	752	7	225.60
White perch	136	16	93.84
Atlantic silverside	72	4	12.24
Bay anchovy	71	3	9.23
Blueback herring	34	5	7.14
Needlefish	20	6	5.20
Bluefish	17	4	2.89
Spottail shiner	30	2	2.40
Striped killifish	14	4	2.38
Golden shiner	7	3	0.91
Striped bass	6	3	0.78
Gizzard shad	4	3	0.52
Norfolk spot	4	2	0.32
Pumpkinseed	4	2	0.32
Croaker	2	2	0.16
Shiner species	1	1	0.04
<u>Alosa</u> species	1	1	0.04
Yellow perch	1	1	0.04
Mummichog	1	1	0.04
Hogchoker	1	1	0.04
Clupeid species	1	1	0.04
TOTAL: 22 species	1941		

*Relative abundance = total number \times $\frac{\text{number of occurrences}}{\text{total \# of sample}}$

TABLE 3-18

TOTAL NUMBERS, NUMBERS OF OCCURRENCES, AND RELATIVE ABUNDANCE
OF FISH IN 24 OTTER TRAWL SAMPLES FROM THE PATAPSCO RIVER AT 6
STATIONS

Fish	Total	Occurrence	Relative* Abundance
White perch	5008	23	4757.60
Norfolk spot	140	9	51.80
Striped bass	78	13	42.12
Bay anchovy	152	6	38.00
Hogchoker	82	9	30.34
American eel	48	12	24.00
Menhaden	33	15	20.46
Croaker	49	5	9.80
Brown bullhead	34	6	8.50
Yellow perch	33	6	8.25
Spottail shiner	8	1	0.32
Blueback herring	1	1	0.04
Bluefish	1	1	0.04
TOTAL: 13 species	5667		

*Relative abundance = total number x $\frac{\text{number of occurrences}}{\text{total \# of sample}}$

TABLE 3-19
TOTAL NUMBERS, NUMBER OF OCCURRENCES, AND RELATIVE ABUNDANCE
OF FISH IN 24 COBB TRAWL SAMPLES FROM THE PATAPSCO RIVER AT 6
STATIONS

Fish	Total	Occurrence	Relative* Abundance
Bay anchovy	169	8	55.77
White perch	57	11	25.65
Blueback herring	32	7	9.28
Menhaden	16	10	6.56
Striped bass	4	4	0.64
Tidewater silverside	5	3	0.60
American eel	2	2	0.16
Norfolk spot	1	1	0.04
TOTAL: 8 species	286		

*Relative abundance - total number \times $\frac{\text{number of occurrences}}{\text{total \# of sample}}$

the temperature (in °C) and salinity in relation to the number of species and total number of fish collected in seined samples.

A total of 5667 fish of 13 species were caught with the otter trawl at six stations from May to August 1972 during four sampling periods. The 24 samples are summarized in Table 3-18.

The Cobb trawl caught 286 fish of 8 species from May to August 1972 during four sampling periods at six stations. These data are summarized in Table 3-19.

The species occurrence by numbers at all of the Cobb trawl, otter trawl, and seine stations for the last two spring months (May and June) and the first two summer months (July and August) is in Tables 3-20 through 3-23. The total catch per station per month by gear is also included.

Discussion. Whereas no one type of fish-collection gear adequately samples all the various life stages and all the various niches available to the fishes in a sampling area, several different sampling methods must be employed and the results of each method examined separately as well as in relation to the others. Ichthyoplankton towing and beach seining are methods that best determine the extent of spawning and nursery activity, while beach seining also samples the shore zone and other forage species; the Cobb midwater trawl collects fishes in the pelagic zone, and the otter trawl (semi-balloon) samples the adults of many species but concentrates on the bottom-dwelling species. When the results of all methods are considered, a reasonable understanding of the fishes in the area and the respective life stages thereof can be obtained.

The relatively small numbers of eggs (5) and larvae (124) of all species as collected during the six-month period (March through August 1972) would suggest that the lower Patapsco River is not a spawning ground of critical

TABLE 3-20
SPECIES OCCURRENCE BY NUMBERS AT STATIONS FOR MAY

Station Number Gear Type	20	21	22	23	24	25	26	27	29	30	31	32
	Cobb/Otter	Cobb/Otter	Seine	Seine	Cobb/Otter	Cobb/Otter	Seine	Seine	Seine	Cobb/Otter	Cobb/Otter	Seine
Species												N O T S A M P L E D
<u>A. aestivalis</u>	4	1	1		1	2	3	23	8	21	2	
<u>B. tyrannus</u>	3	2	1		1	1					1	1
<u>D. cepedianum</u>												
<u>A. mitchilli</u>		2				27	10	58		120	15	102
<u>N. crysoleucas</u>				1								
<u>N. hudsonius</u>								29				
<u>Notropis sp.</u>												
<u>I. nebulosus</u>						1				12		13
<u>A. rostrata</u>		8			13	3				2		2
<u>S. marina</u>												
<u>F. heteroclitus</u>								1				
<u>F. majalis</u>								10	1			
<u>M. americanus</u>	1	1	8	49	6	195	1	23		2	176	1
<u>M. saxatilis</u>			9			1		3		4		
<u>L. gibbosus</u>												
<u>F. flavescens</u>			10			1						
<u>P. saltatrix</u>												
<u>L. xanthurus</u>												
<u>M. undulatus</u>			1									39
<u>M. beryllina</u>			302	9	2	2	3	69	14		1	
<u>M. menidia</u>												
<u>T. maculatus</u>				1	1	1				34		14
Total Catch	8	3	11	78	309	16	18	203	45	211	143	243
											7	387

TABLE 3-21
SPECIES OCCURRENCE BY NUMBERS AT STATIONS FOR JUNE

Station Number Gear Type	Species	20	21	22	23	24	25	26	27	29	30	31	32
		Cobb/Otter	Cobb/Otter	Seine	Seine	Cobb/Otter	Cobb/Otter	Seine	Seine	Cobb/Otter	Cobb/Otter	Cobb/Otter	Seine
A. aestivalis		1	1										6
B. tyrannus		1		1	25	1	1	2	20	630	1	1	2
D. cepedianum													58
A. mitchilli						1						1	9
N. crysoleucas					2								
N. hudsonius				1									
Notropis sp.									1				
I. nebulosus													
A. rostrata		5					5				2	3	
S. marina													
F. heteroclitus													
F. majalis									1				
M. americanus		68	191	4	10		2	549	1	5	311	6	264
M. saxalitis		1	6			1	1	18	1				17
L. gibbosus													
P. flavescens			1								2		
P. saltatrix					1				3	11			2
L. xanthurus												2	
M. undulatus				1					1		2	5	
M. beryllina					6				20	30			13
M. menidia													
I. maculatus											16		
Total Catch		2	75	1	198	7	44	3	45	3	590	4	51
										671	1	8	293
													90

TABLE 3-22
SPECIES OCCURRENCE BY NUMBERS AT STATIONS FOR JULY

Station Number Gear Type	20	21	22	23	24	25	26	27	29	30	31	32
Species	Cobb/Otter	Cobb/Otter	Seine	Seine	Cobb/Otter	Cobb/Otter	Seine	Seine	Cobb/Otter	Cobb/Otter	Cobb/Otter	Seine
<u>A. aestivalis</u>												
<u>B. tyrannus</u>	1	3	1	1	2			1		3		
<u>D. cepedianum</u>			2									
<u>A. mitchilli</u>											12	
<u>N. crysoleucas</u>												
<u>N. hudsonius</u>												
<u>Notropis sp.</u>												
<u>I. nebulosus</u>										4		
<u>A. rostrata</u>	1				1	1						
<u>S. marina</u>			7			1						
<u>F. heteroclitus</u>												
<u>F. majalis</u>												
<u>M. americanus</u>	19	40	11	1	2	204				104	6	924
<u>M. saxatilis</u>		1			1						1	2
<u>L. gibbosus</u>								2				
<u>P. flavescens</u>		1										
<u>P. saltatrix</u>										1		
<u>L. xanthurus</u>		1			11	12		1		2		7
<u>M. undulatus</u>												
<u>M. beryllina</u>			4	10			69	75	8			8
<u>M. menidia</u>			18	18			28	8				
<u>T. maculatus</u>					9	2				2		
Total Catch	1	20	3	44	41	31	3	103	2	219	98	116
									8	0	116	931
												17

TABLE 3-23
SPECIES OCCURRENCE BY NUMBERS AT STATIONS FOR AUGUST

Station Number Gear Type	20	21	22	23	24	25	26	27	29	30	31	32						
	Cobb/Otter	Cobb/Otter	Seine	Seine	Cobb/Otter	Cobb/Otter	Seine	Seine	Seine	Cobb/Otter	Cobb/Otter	Seine						
<u>A. aestivalis</u>																		
<u>B. tyrannus</u>	3	1	4	16	2	7				1		4						
<u>D. cepedianum</u>				1														
<u>A. mitchilli</u>						3				18	4	4						
<u>N. crysoleucas</u>			4									4						
<u>N. hudsonius</u>										8								
<u>Notropis sp.</u>																		
<u>I. nebulosus</u>						3				1								
<u>A. rostrata</u>		1				3												
<u>S. marina</u>			4					4	2			2						
<u>F. heteroclitus</u>																		
<u>F. majalis</u>								2										
<u>M. americanus</u>			5	10	9	10	580			246		564						
<u>M. saxalitis</u>		2								1								
<u>L. gibbosus</u>								2										
<u>P. flavescens</u>																		
<u>P. saltatrix</u>																		
<u>L. xanthurus</u>	1	2				27		3				76						
<u>N. undulatus</u>												2						
<u>M. beryllina</u>			11	6			1	87	15			2						
<u>M. menidia</u>																		
<u>T. maculatus</u>																		
Total Catch	4	1	0	14	29	32	0	12	0	623	1	111	17	0	275	4	650	8

importance to any particular species. However, salinities in the entire upper bay region were drastically lowered by tropical storm Agnes in late June; obviously, this and other tremendous changes in water quality has undoubtedly altered what might otherwise be called "normal" spawning and nursery activity in the area.

Prior to Agnes there was little spawning activity in the lower Patapsco, although adjacent areas of the upper bay are indeed heavily utilized by the freshwater-spawning yellow perch (Perca flavescens) and the anadromous species - white perch (Morone americanus), striped bass (Morone saxatilis), and the herrings and shads (Alosa sp.). Spawning areas of these species are characterized by a strong freshwater inflow, for it is this inflow which, in part, lures the adults to the spawning ground. The high springtime flows of the Susquehanna River indeed provide the necessary attraction and the volumes of freshwater which make for an excellent spawning area. By sharp contrast, the Patapsco River has a river flow that is probably a mere fraction of that of the Susquehanna River; as a result, few anadromous species are attracted to the upper Patapsco River for spawning. Dovel (1971a) did find a few larval white perch; in the present study herring eggs and larvae and white perch larvae were collected (Table 3-15), but in such small numbers as to be judged rare. Menhaden (Brevoortia tyrannus) larvae of a large size (30 to 35 mm) were found in the early sampling and this agrees with prior work by Dovel (1970). Thus, this region of the Patapsco River can be called relatively unimportant as a spawning or nursery ground for the commonly found anadromous species typical of the upper Chesapeake Bay.

After Agnes, ichthyoplankton data indicate that the area is the site of spawning and nursery activity by the tide-water silverside (Menidia beryllina) and the naked goby (Gobiosoma bosci). These two species - one pelagic and one epi-benthic - are very widely spread in the brackish area of the Chesapeake Bay in salinities of 0 to 15 ppt.

The eggs of the silverside have long filaments by which they are attached to vegetation and the like on the bottom. They are rarely collected by towed plankton nets. The larvae, however, are taken during most of the warm-water months. The goby is one of the more prolific species in the bay, but this small oyster-bed inhabitant leads a rather retiring type of existence and as a relatively young fish (only 15 mm long) it lives in and on the bed and is rarely taken by conventional collection methods.

Dovel (1971b) in his studies of the upper bay found great numbers of the goby and also of the silverside though to a lesser extent, and the two species appear widely spread in the Patapsco River also (BioCon, 1971; present study, 1972). It is important, however, to note the conspicuous absence of the eggs and larvae of two other estuarine spawners - the bay anchovy, like the silver side, is a pelagic species feeding largely on zooplankton; the hogchoker, like the goby an epi-benthic species, is a small flat fish feeding mainly on annelid worms and other benthic invertebrates. Dovel found the eggs and larvae of the anchovy to be one of the most abundant species captured in ichthyoplankton samples in the low salinity areas of the Chesapeake Bay (1971b). They were also found in great numbers in the lower Patapsco River in 1970. The hogchoker also is normally widespread as eggs and young in salinities up to 15 ppt. The present study as well as Bio-Con (1971) found no eggs of either species, and only a few anchovy larvae indicating that spawning and nursery activities of these two species were for some reason at a greatly reduced level in the lower Patapsco River. The fact that the bottom sediments could be unsuitable for the young hogchoker larvae was postulated by Dovel (1971a) as a reason for their absence, though eggs were found at the lowermost stations. However, it is felt that the high levels of precipitation during 1971 and rain from tropical storm Agnes reduced salinities in the lower Patapsco River to a point that was below the preferred salinity for spawning of these two species. It is interesting to note that larvae of two species (tidewater silverside and naked goby) were found,

but those of the anchovy and hogchoker were not, though habitat requirements were similar (with the exception of the latter two preferring slightly higher salinities for spawning). Lowered salinities (1 to 8 ppt versus 2 to 15 ppt as reported by Dovel, 1971a) have been therefore cited as reasons for the absence of eggs and larvae of two species which could have been expected to spawn in the lower Patapsco River. Otherwise the ichthyoplankton data is as expected, with the Patapsco River serving as a spawning and nursery area of very minor importance for the springtime spawning anadromous species.

Beach seine data indicates that the tidewater silver-side is the dominant species in terms of both numbers and distribution. Juvenile menhaden of two-year classes were the second most numerous but were found in less than one-third of the samples. One haul, in fact, yielded 83.8% of all menhaden caught during the first 4 months of seining. This is typical for schooling species such as the menhaden, and it can distort otherwise normal distributions. The menhaden were in the 40 to 60 mm range during June and were the same year class as the 30 mm larvae found in March in the ichthyoplankton tows. This filter feeder shows a rather large increase in total length from 30 to 35 mm in March to 40 to 60 mm in June, to ca. 75 mm in July, and to 100 mm in August, indicating the importance of the lower Patapsco River as a nursery area for the 0-year class menhaden. The 1-year class fish were also captured, though in smaller numbers and were roughly 170 mm in May and 200 mm in August. Again, the menhaden (now 1-1/2 years old) exhibit rather substantial growth increases, although not nearly so great as in the first year.

White perch was the third most numerous species caught by the beach seine and was found in 2/3 of the samples. In July, 0-year class white perch were in the range of 18 to 22 mm and by August had grown to approximately 30 mm. Length frequencies on seine trawl data indicate that 1-year class white perch were about 80 mm shortly after becoming one year old and grew to approximately 90

mm in June, and perhaps 110 to 130 mm in July and August. The actual length of the I-year class fish is difficult to determine from length frequencies because of overlap size ranges for any particular year class. White perch older and larger were also caught in large numbers, but classification into age groups is difficult because of the aforementioned overlap of size ranges. Also present in the seine samples, but in reduced numbers (tidewater silverside, Atlantic menhaden and white perch accounted for 85.0% of all fishes seined) were the Atlantic silverside (Menidia menidia), bay anchovy, blueback herring (Alosa aestivalis), bluefish (Pomatomus saltatrix), Atlantic needlefish (Strongylura marina), spottail shiner (Notropis hudsonius), and the striped killifish (Fundulus majalis). These fishes, as well as the other species caught (those fewer than 10 in number in all 4 monthly samples), represent a portion of the species of fishes commonly found in the upper Chesapeake Bay and its tributaries. It is a mixture of freshwater forms (gizzard shad, pumpkinseed, golden and spottail shiners), resident estuarine forms (tidewater silverside, bay anchovy, blueback herring, Atlantic needlefish, striped bass, striped killifish, mummichog, yellow perch, and hogchoker) and the marine forms (bluefish, Norfolk spot, and Atlantic croaker). While not as complete a list as previous researchers have compiled, the species collected by seining to date suggest a reasonably normal ichthyofauna for the shore zones of the lower Patapsco River.

Numbers of species and numbers of fishes show little correlation with temperature at the seining station at the time of collection. However, at the maximum temperature found (33.5°C) there was only one fish — a silverside — in a beach seine haul. Temperatures of 31.5°C (August, Station 22) and 29.6°C (July, Station 27) did not show a similar reduction in sample size. Furthermore, in August 1971 seining (BioCon, 1971) at 31.7°C, a seine haul at Station 26 caught 110 fishes of 6 species.

With regard to species distribution among the seining stations during the sampling period, only the tidewater

silverside and white perch were found in more than half of the samples. May samples were dominated by a slug of 302 silversides at Station 22. Thereafter, the catches of this resident forage species were much lower (a maximum of 87), but the larger catches seemed to be concentrated at Stations 26, 27, or 29, and represented the bulk of all fishes seined at those stations. White perch were far less numerous than silversides, and the distribution at the stations on a given date is correspondingly obscure. Thirty-five white perch were found at 4 of 5 stations in May; 21 were seined at 5 of 6 stations in June, 19 were found at 3 of 6 stations in July, and 19 at 2 of 6 stations in August. In the last two sampling periods no white perch were found at the three stations closest to the discharge (Stations 26, 27, and 29); however, during 1971 sampling, 198 white perch were seined at Station 26 in July when water temperatures were quite high (34.5°C). Therefore, the possible theory of thermal avoidance can be somewhat discounted.

Atlantic menhaden, though second most numerous, were found almost exclusively in the June samples when a total of 746 were seined at all six stations. Thereafter, only 1 was found in July and 16 in August. The high number of menhaden found at one station (630 at Station 29 in June) has been explained by the schooling nature of the species, but the greatly reduced numbers in subsequent months could be as a result of tropical storm Agnes. Seining in June followed Agnes by only a few days, and the menhaden were still in the area; but the schools of menhaden could have begun moving to more saline waters shortly thereafter.

Distribution patterns for the other species are rather difficult to see from the seine data because of the small numbers of each species. Among these species of lesser numbers, it is noted that the Atlantic silverside was found only during July sampling, and Atlantic needlefish was found only in July and August, a time when this predator species is usually haunting the shallows looking

for small top minnows, anchovies, and silversides. Little else can be gathered from the seine data to date.

The trawls used each sampled a different portion of the water column, and the species composition of the catches reflect this difference. As expected, the Cobb trawl caught mostly pelagic fishes (217 out of 286 total) although the white perch was second in number and occurrences; and two other bottom species, American eel and Norfolk spot, were also caught. The otter trawl, however, was far more successful than the Cobb, the total catches being 5667 versus 286 fishes, respectively. The otter trawl also caught pelagic fishes, in fact, more menhaden at more stations than the Cobb trawl. The bay anchovy was present in both trawl samples in comparable numbers and occurrences. Of major importance is the presence of young-of-the-year croakers in the otter trawl samples in May and June from the lowermost stations (30 and 31). The presence of these fish spawned last fall (1971) indicates somewhat of a return of this species, since neither Dovel (1971a) nor Wiley (1971) reported any in their samples.

Although white perch were present in 23 of 24 samples, the upper stations (20 and 21) produced consistently smaller catches than either the middle pair (24 and 25) or the lowermost pair (30 and 31). In addition, each of the stations on the northeast side of the main channel (20, 24, and 30) closest to Sparrows Point all showed smaller catches (with one exception) than the corresponding station on the southwest side of the channel (21, 25, and 31). It would appear that the white perch are distributed somewhat inversely with the industrial pollution load of the upper, middle, and lower Patapsco River; and the present data seems to agree well with Wiley (1971). Total numbers of white perch trawled by month increased from 848 in May 50 1431 in June, but thereafter remained amazingly constant at 1381 in July and 1405 in August, indicating the rather static nature of that resident population during the warm months.

Norfolk spot increased in numbers from May to August, and much like the white perch, were more numerous in the downriver stations, especially those on the southwest side of the channel (21, 25, and 31). Striped bass were present in 13 of the 24 total samples, but in numbers greatly reduced in July and August. This may be in response to either lowered salinities or reduced food fishes such as anchovies and blueback herring which were also found in reduced numbers after tropical storm Agnes. The American eels were also less numerous in July and August sampling (2-month total of 7 versus 43 in May and June), and again the lowered salinities may have been a factor.

Monthly length-frequencies for eight species of fishes as collected by all gears are given in Figs. 3-28 through 3-35. As mentioned previously, length-frequencies will separate the year classes of fishes (especially in the early years) by the large differences in length. With certain concessions, the biologist can also determine a size range, a mean length (actually a modal length), and when examined over time, a growth curve can be defined.

White perch length-frequencies (Fig. 3-28) show that the May samples were dominated by fish just over a year old (ca. 80 mm) and just over 2 years old (ca. 130 mm) although older fish are present in the samples. As the season progresses, these two year classes merge somewhat and cannot be visually separated, but the young-of-the-year spawned in March and April 1972 are also noted in the samples (ca. 10 mm in June, 20 mm in July, and 30 mm in August).

In Fig. 3-29, menhaden length-frequencies for June indicate a strong 0-year class (fish spawned in the fall of 1971) and a sprinkling of older fish. The reduction in numbers seen in July is probably a result of fish leaving the area sampled and not due to reduction in gear efficiency. In August, these fish have returned to the area

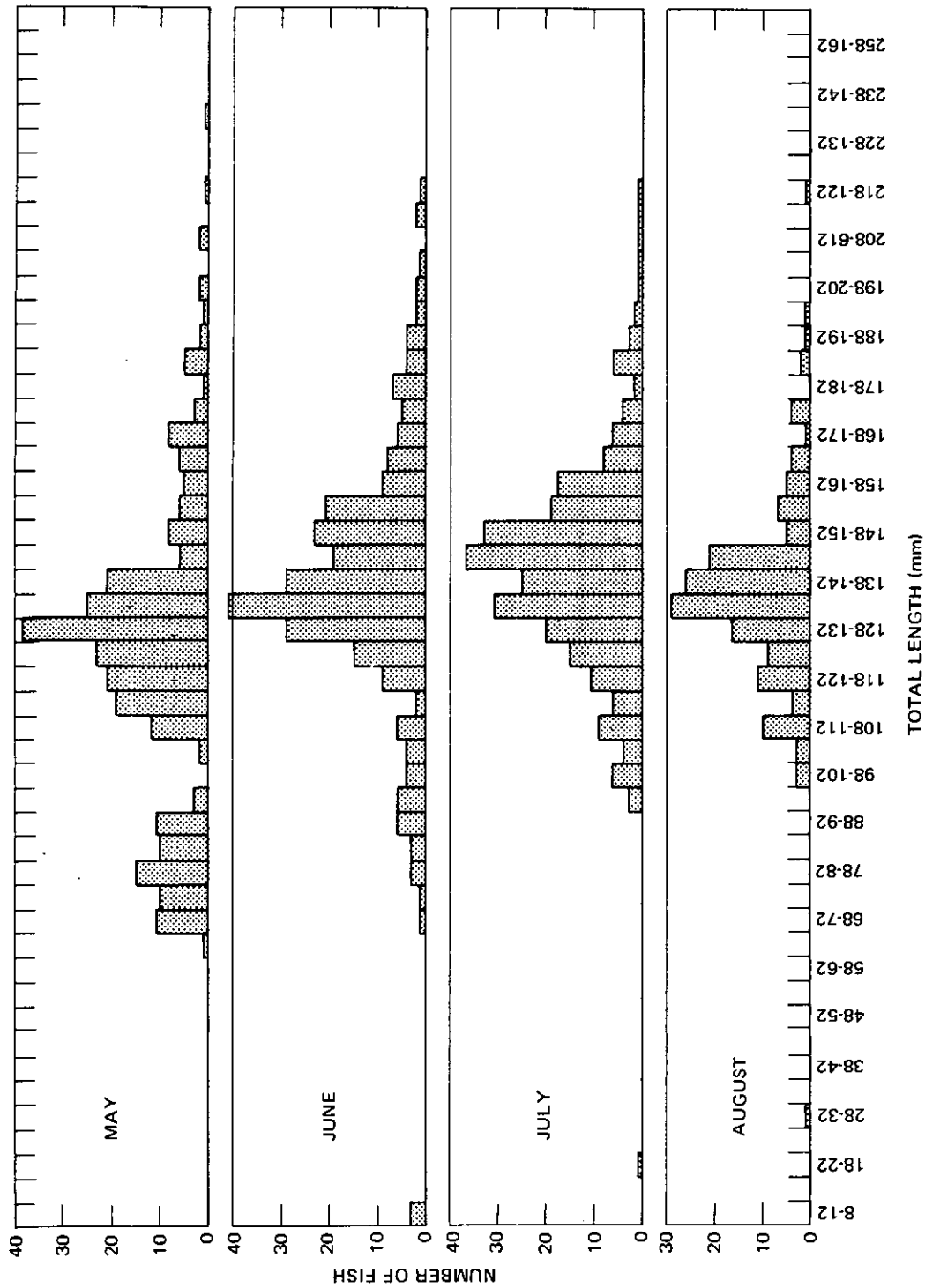


Figure 3-28 MONTHLY LENGTH FREQUENCIES FOR WHITE PERCH COLLECTED BY ALL SAMPLING GEAR IN THE PATAPSCO RIVER ESTUARY MAY - AUGUST 1972.

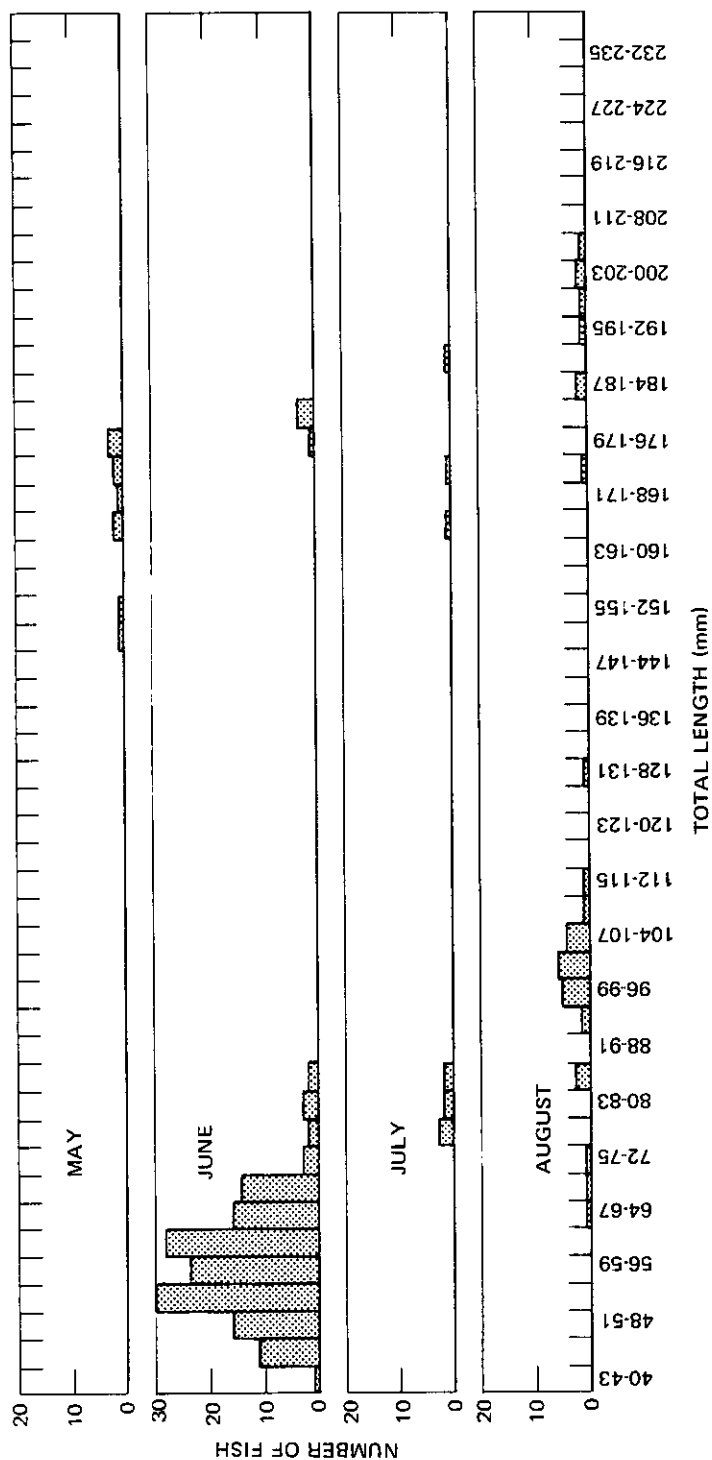


Figure 3-29 MONTHLY LENGTH FREQUENCIES FOR MENHADEN COLLECTED BY ALL SAMPLING GEAR IN THE PATAPSCO RIVER ESTUARY, MAY - AUGUST 1972.

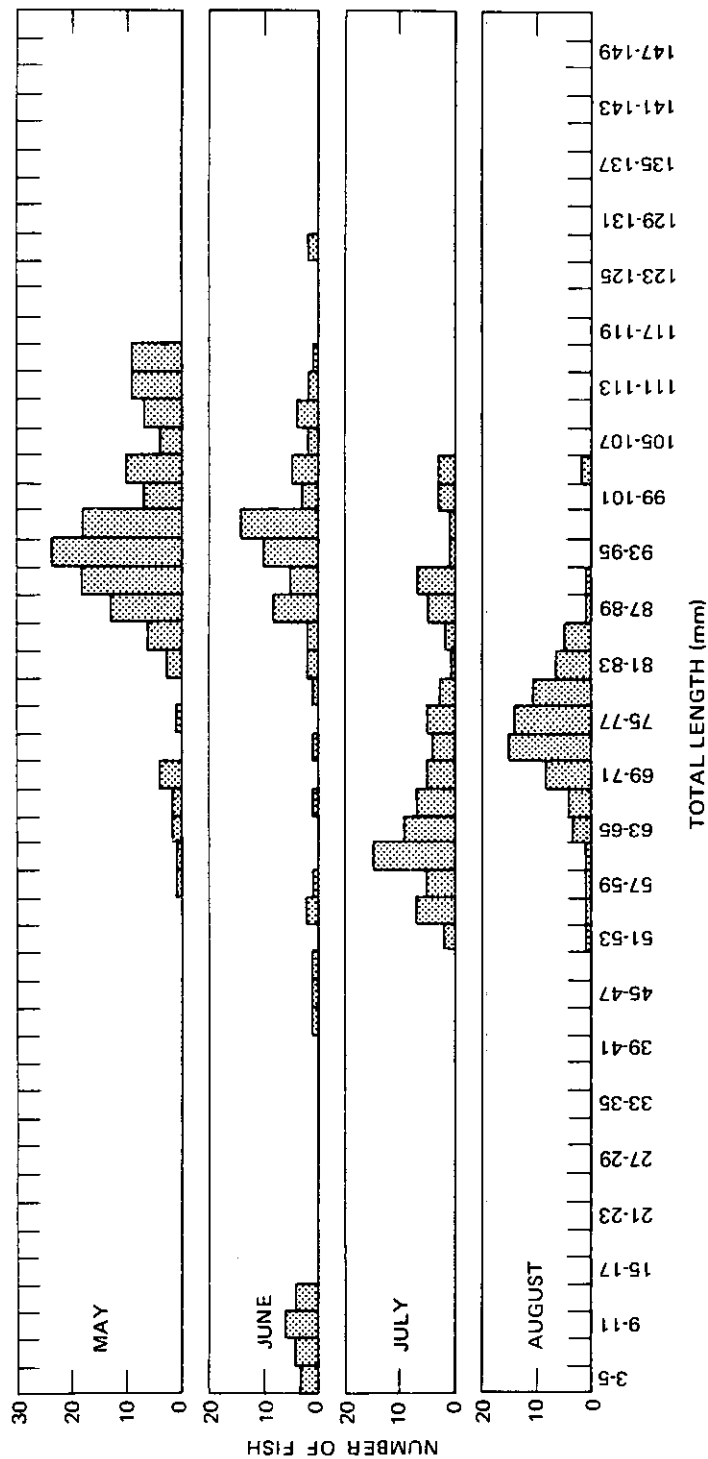


Figure 3-30 MONTHLY LENGTH FREQUENCIES FOR TIDEWATER SILVERSIDES COLLECTED BY ALL SAMPLING GEAR IN THE PATAPSCO RIVER ESTUARY, MAY - AUGUST 1972.

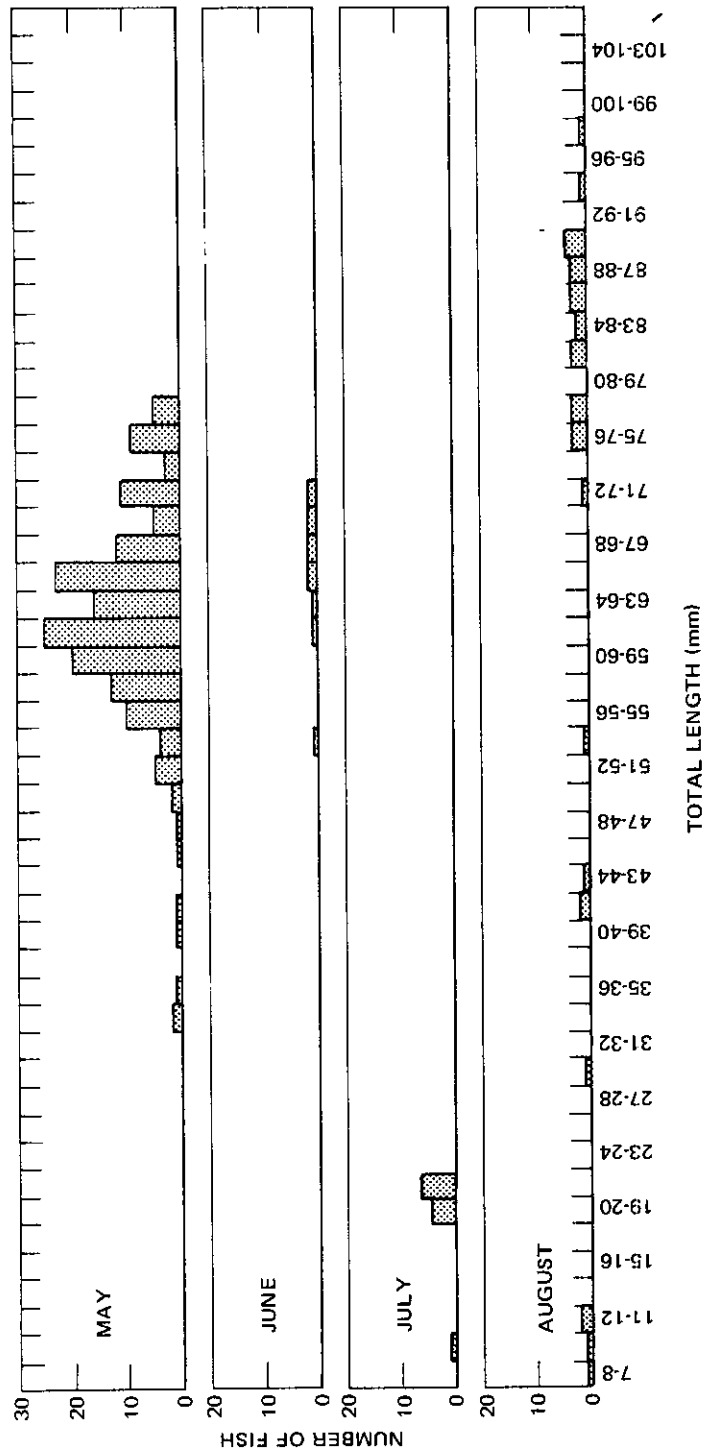


Figure 3-31 MONTHLY LENGTH FREQUENCIES FOR BAY ANCHOVIES COLLECTED BY ALL SAMPLING GEAR IN THE PATAPSCO RIVER ESTUARY, MAY - AUGUST 1972.

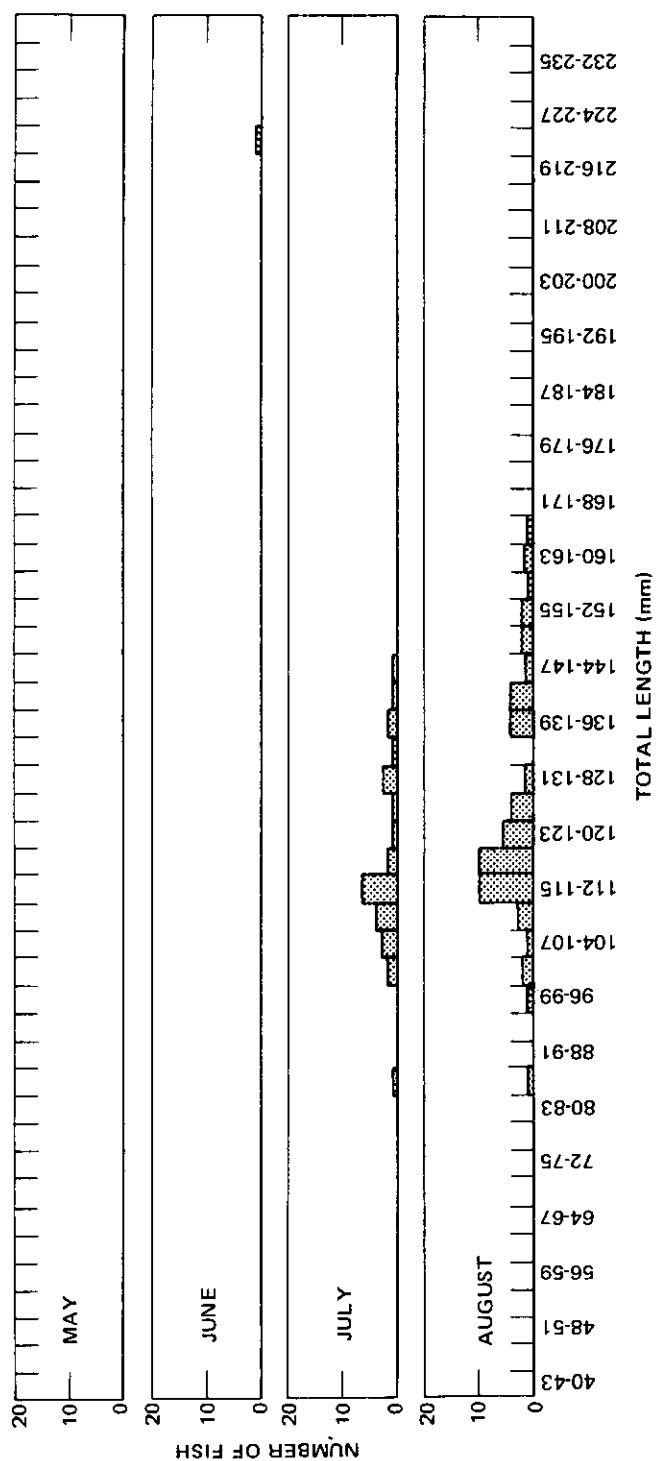


Figure 3-32 MONTHLY LENGTH FREQUENCIES FOR NORFOLK SPOT COLLECTED BY ALL SAMPLING GEAR IN THE PATAPSCO RIVER ESTUARY, MAY - AUGUST, 1972.

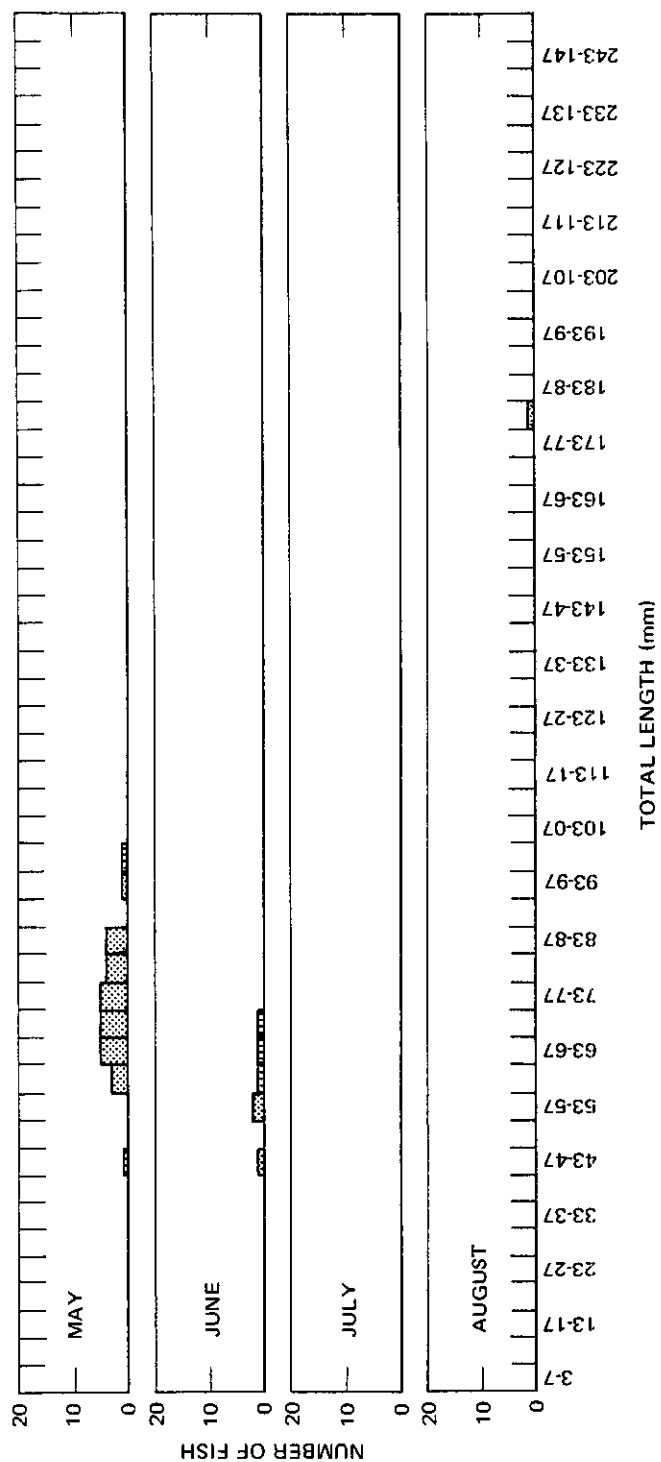


Figure 3-33 MONTHLY LENGTH FREQUENCIES FOR ATLANTIC CROAKERS COLLECTED BY ALL SAMPLING GEAR IN THE PATAPSCO RIVER ESTUARY, MAY - AUGUST, 1972.

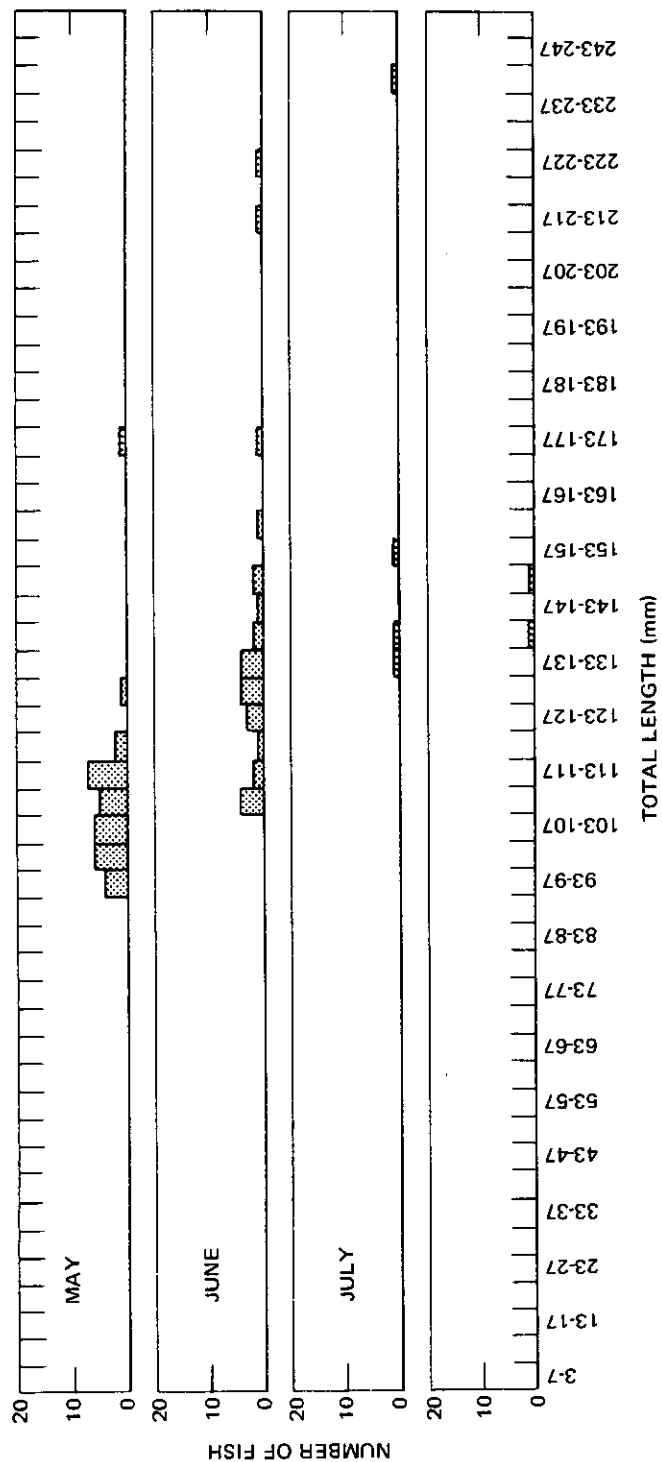


Figure 3-34 MONTHLY LENGTH FREQUENCIES FOR STRIPED BASS COLLECTED BY ALL SAMPLING GEAR IN THE PATAPSCO RIVER ESTUARY, MAY - AUGUST 1972.